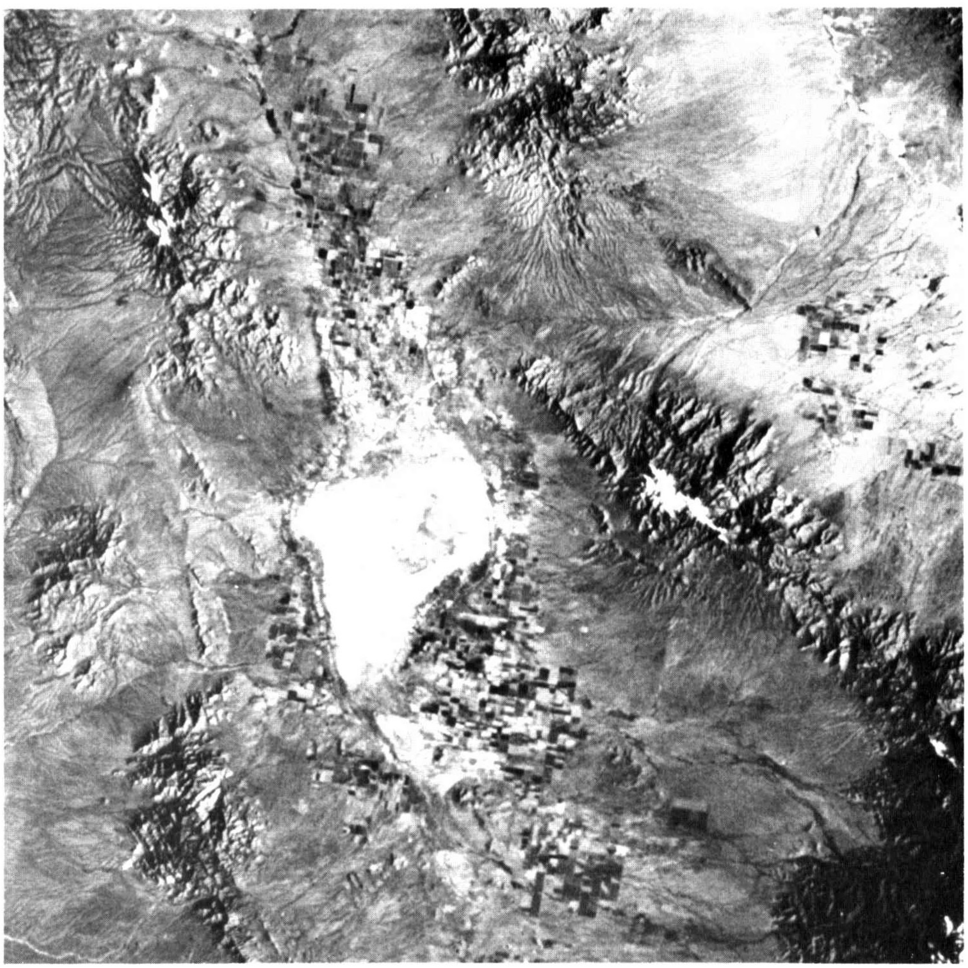
SOIL SURVEY OF

Willcox Area, Arizona

Parts of Cochise and Graham Counties



United States Department of Agriculture
Soil Conservation Service
In cooperation with
Arizona Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1965–70. Soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1971. This survey was made cooperatively by the Soil Conservation Service and the Arizona Agricultural Experiment Station. It is part of the technical assistance furnished to the Willcox-San Simon Natural Resource Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and ranches; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of the Willcox Area are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise it is outside, and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay on the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units and range sites.

Ranchers and others can find, under "Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Community planners and others can read about soil properties that affect the choice of sites for dwellings, industrial buildings, and recreation areas in the engineering section.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation, Morphology, and Classification of the Soils."

Newcomers in the Willcox Area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the survey area given in the section "Additional Facts About the Area."

Cover: NASA photograph taken from Apollo 6 at an altitude of 136 miles shows the northern part of the Sulphur Spring Valley and part of the area covered by the survey. The cultivated areas to the north, southwest, and southeast of the Willcox Playa show up as a checkerboard pattern.

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PARTS OF COCHISE AND GRAHAM COUNTIES

BY DAVIE L. RICHMOND, SOIL CONSERVATION SERVICE

SOILS SURVEYED BY DAVIE L. RICHMOND, MERLYN L. RICHARDSON, RICHARD K. PREECE, AND KENT L. DUNSTAN, SOIL CONSERVATION SERVICE [1]

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE ARIZONA AGRICULTURAL EXPERIMENT STATION

THE WILLCOX AREA includes most of the northern half of Sulphur Spring Valley in Cochise County and a small part of Graham County (fig. 1). The Area is roughly triangular and averages about 15 miles from east to west and 40 miles from north to south. The total extent is about 574 square miles, or 367,370 acres.

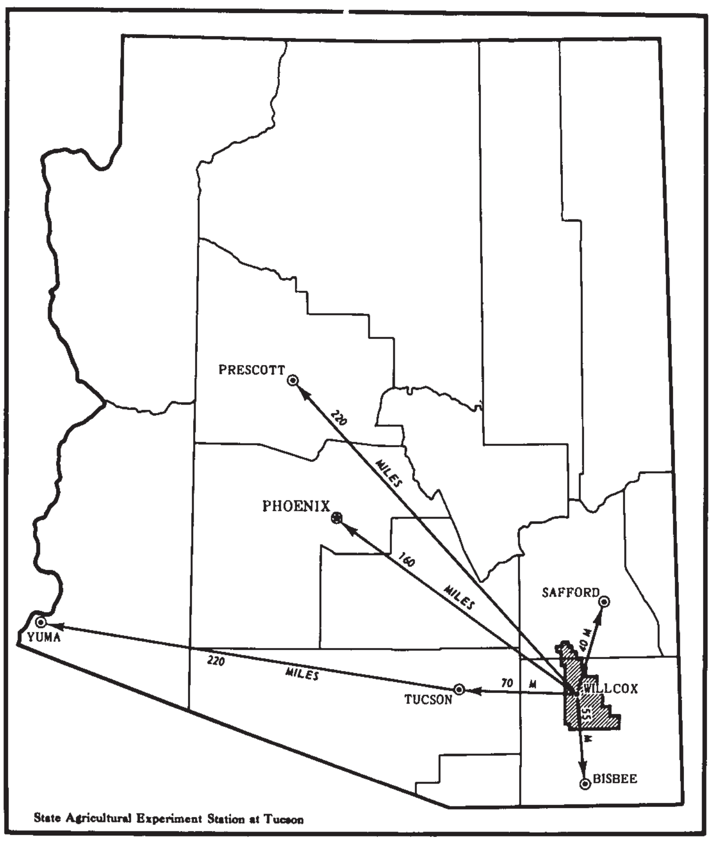

Figure 1.—**Location of Willcox Area in Arizona.**

The Area is in a closed basin. The Willcox Playa is the lowest part of this basin. Although the survey area covers only the lower part of the basin, the influence of the surrounding mountains is felt. Sulphur Spring Valley is bounded on the north by the Pinaleno Mountains, on the east by the Dos Cabezas and Chiricahua Mountains, on the northwest by the Galiuro and Winchester Mountains, and on the west by the Dragoon Mountains.

Average annual precipitation is 12 to 14 inches, average annual air temperature is 60° to 62° F., and the frost-free season is 175 to 200 days.

Willcox is the largest community in the Area. In 1970 it had a population of 2,568. Other communities in the Area are Pearce-Sunsites and Cochise.

The soils in the Area are mainly nearly level, but some are moderately steep. Most soils are suitable for many crops, but the saline-alkali affected soils adjacent to the Willcox Playa and the steeply sloping soils are not. Much of the acreage is used for crops, and all crops are irrigated. The rest is used as range for beef cattle.

Livestock grazing was the main enterprise in the Area until about 1920, when the production of irrigated crops began to increase. Grain sorghum is the principal irrigated crop, and most of it is shipped to cattle feedlots near Phoenix. Corn, barley, wheat, cotton, sugar beets, lettuce, and alfalfa are other important irrigated crops. On smaller acreages vegetables and some fruits are grown.

Throughout the Area, State highways and secondary roads connect all communities and farming areas, and an interstate highway helps speed traffic to major centers. Buses, trucklines, an airline, and a railroad provide shipping facilities and transportation.

Electric power, gas and oil, telephone service, a hospital, and other modern conveniences are available throughout the Area. Schools, churches, and social and business groups are also well distributed. Mountains adjacent to the Area provide opportunities for hiking, hunting, fishing, and other recreation.

[1] GARY L. JACKSON, SCS, also contributed to the fieldwork for this survey.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in the Willcox Area, where they are located, and how they can be used. The soil scientists went into the Area knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in nearby counties and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Elfrida and Tubac, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Forrest gravelly sandy clay loam, 2 to 5 percent slopes, is one of several phases within the Forrest series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soils of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. One such kind of mapping unit, a soil complex, is shown on the soil map of the Willcox Area.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Bernardino complex, 0 to 10 percent slopes, is an example. It consists of Bernardino gravelly sandy loam and Bernardino gravelly sandy clay loam.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Torrifluvents and Torriorthents, hummocky, are land types in this survey area.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or a high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the Willcox Area. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in an area, who want to compare different parts of an area, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wildlife area, or in planning engineering works, recrea-

tional facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soils in this survey have been grouped into eight general kinds of landscape for broad interpretative purposes. Each soil association is described in the following pages.

1. *Gothard-Crot-Stewart association*

Nearly level, moderately well drained and somewhat poorly drained, deep to very shallow, very slowly permeable, saline-alkali affected soils

This association occupies the flat Willcox Playa and the nearly level saline-alkali flats that border the playa. The saline-alkali affected soils are very shallow to deep and are moderately well drained to somewhat poorly drained. They formed in lacustrine sediment and alluvium derived from mixed sources. Slopes range from 0 to 2 percent but are generally less than 0.5 percent. Elevation ranges from 4,136 to 4,200 feet. The vegetation is alkali sacaton, inland saltgrass, alkali lovegrass, tobosa, saltbush, and scattered mesquite.

This association covers about 29 percent of the survey area. It is about 30 percent Gothard soils, 20 percent Crot soils, and 10 percent Stewart soils. The Willcox Playa and traces of Duncan and Cogswell soils and Torriorthents, hummocky, make up about 40 percent of the association.

Gothard soils are generally farthest from the Willcox Playa. They are moderately well drained fine sandy loams. Crot soils are nearest to the Willcox Playa. They are somewhat poorly drained sandy loams. Stewart soils are generally between Crot and Gothard soils. They are somewhat poorly drained loams that are very shallow over a silica and lime-cemented hardpan about 13 inches thick.

The Willcox Playa consists of poorly drained, saline-alkali affected, barren soils that are subject to periodic flooding. It is the lowest part of a closed basin that drains about 1,800,000 acres. Excess water from precipitation and irrigation flows into the playa, where it stands until it evaporates.

This association is used for range and for homesites and other community purposes. Large areas have been subdivided into small tracts for housing developments. The soils are a source of sand, gravel, and road fill. They are only marginally suited to irrigated crops because of the salt and alkali content.

2. *Pima-Guest association*

Nearly level, well-drained, deep, slowly permeable and moderately slowly permeable soils on flood plains and low terraces

This association occupies nearly level flood plains and low terraces. The soils are deep, well drained, and dark colored. They formed in mixed alluvium. Slopes are 0 to 2 percent. The vegetation is vine-mesquite, curly mesquite, tobosa, black and blue grama, cane beardgrass, and mesquite.

This association covers about 8 percent of the survey area. It is about 80 percent Pima soils, 15 percent Guest soils, and 5 percent Cogswell soils.

Pima soils are deep, well-drained loams. Guest soils are deep, well-drained clay loams.

This association is used for irrigated crops, for range, and for homesites and other community purposes.

3. *Grabe-Comoro association*

Nearly level, well-drained, deep, moderately permeable and moderately rapidly permeable soils on flood plains and low terraces

This association occupies nearly level flood plains and low terraces on fingerlike projections that point toward the Willcox Playa. The soils are deep and well drained. They formed in mixed alluvium. Slopes are 0 to 2 percent. Elevation ranges from 4,200 to 4,600 feet. The vegetation is giant sacaton, black and blue grama, cane beardgrass, sand dropseed, burroweed, yucca, and mesquite.

This association covers about 13 percent of the survey area. It is about 55 percent Grabe soils, 30 percent Comoro soils, and 15 percent Tubac and Sonoita soils.

Grabe soils are deep, well-drained, stratified loams and sandy loams. Comoro soils are deep, well-drained, stratified sandy loams and gravelly sandy loams.

This association is used for irrigated crops and for range. Some areas have been subdivided into small tracts for homesites and other community developments. The Comoro soils are a possible source of sand and gravel.

4. *Vinton-Dry Lake association*

Nearly level and gently sloping, well drained and moderately well drained, deep, slowly permeable and moderately rapidly permeable soils on low terraces

This association occupies low terraces that are nearly level to gently sloping and undulating. The terraces have been reworked by the wind, and they appear as sandy ridges and low dunes. The soils are deep and well drained. They formed in mixed alluvium and lacustrine sediment. Slopes range from 0 to 5 percent. Elevation ranges from 4,170 to 4,300 feet. The vegetation is sand sagebrush, sand dropseed, bush muhly, alkali sacaton, and mesquite.

This association covers about 3 percent of the survey area. It is about 45 percent Vinton soils, 35 percent Dry Lake soils, and 20 percent Crot and Karro soils.

Vinton soils are generally farther from the Willcox Playa than the Dry Lake soils. They are deep, well-drained loamy fine sands. The Dry Lake soils are well-drained loamy sands that are about 24 inches deep over unconformable limy loam.

This association is used mainly for range, but some isolated areas are used for irrigated crops.

5. *Karro-Elfrida association*

Nearly level, well-drained, deep, moderately slowly permeable soils on valley plains and flood plains near old lake margins

This association occupies nearly level flood plains and valley plains near old lake margins. It is in areas adjacent to and just slightly above the Gothard-Crot-Stewart association. The soils are deep and well drained. They

formed in mixed alluvium derived from acid and basic igneous rocks and some limestone. Slopes range from 0 to 2 percent but are generally less than 0.5 percent. Elevation ranges from 4,140 to 4,300 feet. The vegetation is fluffgrass, tobosa, alkali sacaton, creosotebush, gramas, saltbush, blackbrush, and mesquite.

This association covers about 9 percent of the survey area. It is about 50 percent Karro soils, 40 percent Elfrida soils, and 10 percent Pima and Grabe soils.

Karro soils are deep, well-drained, light-colored loams that have lime accumulation within 20 inches of the surface. Elfrida soils are deep, well-drained, dark-colored silty clay loams that have lime accumulation below a depth of 20 inches.

This association is used for irrigated crops, for range, and for homesites and other community purposes. Some areas have been subdivided into small tracts for homesites.

6. *McAllister-Frye association*

Nearly level, well-drained, deep and moderately deep, slowly permeable and moderately slowly permeable soils on valley slopes and plains

This association occupies nearly level valley slopes and plains. It is between the Pima-Guest association of the Ash Creek drainage area and the Tubac-Sonoita-Forrest association of the gently sloping valley plains. The soils are well drained and deep or moderately deep over a hardpan. They formed in alluvium derived from mixed sources, which include granite, quartzite, rhyolite, andesite, and limestone. Slopes are dominantly less than 1.5 percent. Elevation ranges from 4,100 to 4,500 feet. The vegetation is alkali sacaton, tobosa, fluffgrass, burrograss, Rothrock grama, black and blue grama, and mesquite.

This association covers about 4 percent of the survey area. It is about 70 percent McAllister soils, 25 percent Frye soils, and 5 percent Tubac and Pima soils.

McAllister soils are deep, well-drained loams that have a subsoil of clay loam. They are calcareous throughout. Frye soils are moderately deep, well-drained sandy loams that have a clay subsoil. They have a silica and lime-indurated hardpan at a depth of about 26 inches.

This association is used for irrigated crops, for range, and for homesites.

7. *Tubac-Sonoita-Forrest association*

Mostly nearly level to gently sloping, well-drained, deep, slowly permeable to moderately rapidly permeable, mainly reddish-colored soils on fans and valley slopes

This association occupies nearly level to gently sloping valley plains, valley slopes, and alluvial fans of the valley uplands. The soils are deep and well drained. They formed in mixed alluvium derived from quartzite, granite, ignimbrite, andesite, rhyolite, and limestone. Slopes are 0 to 25 percent. Elevation ranges from 4,200 to 4,600 feet. The vegetation is Rothrock grama, blue grama, hairy grama, tobosa, burroweed, and scattered yucca and mesquite.

This association covers about 30 percent of the survey area. It is about 45 percent Tubac soils, 20 percent Sonoita soils, 15 percent Forrest soils, and 20 percent Pima, Cowan, and Pridham soils.

Tubac soils are deep, well-drained, slightly acid to moderately alkaline sandy loams. Sonoita soils are deep, well-drained, slightly acid to moderately alkaline sandy loams or gravelly sandy loams. Forrest soils are deep, well-drained, slightly acid to moderately alkaline loams.

This association is used for irrigated crops, for range, and for homesites and other community purposes. Large areas have been subdivided into small tracts for homesites.

8. *Kimbrough-Luzena-Cave association*

Nearly level to moderately steep, well-drained, shallow and very shallow, moderately permeable and slowly permeable soils over a lime-indurated hardpan or bedrock on alluvial fans, valley plains, and hills

This association occupies nearly level to moderately steep valley plains and alluvial fans and moderately steep hills. It occurs as isolated areas scattered throughout the survey area. The soils are very shallow and shallow and well drained. They formed in alluvium derived from mixed sources or in residuum that weathered from andesite, rhyolite, or associated tuff and agglomerate. Slopes are 0 to 30 percent. Elevation ranges from 4,200 to 4,900 feet. The vegetation is black, blue, and side-oats grama; tanglehead; woolly bunchgrass; cane beardgrass; creosotebush; tarbush; and scattered mesquite.

This association covers about 4 percent of the survey area. It is about 55 percent Kimbrough soils, 25 percent Luzena soils, 15 percent Cave soils, and 5 percent Tubac and Comoro soils.

Kimbrough soils are on higher parts of alluvial fans and valley fill that surround low hills. They are well-drained, dark-colored gravelly loams and loams that have a lime-indurated hardpan above a depth of 20 inches. Luzena soils are on hills. They are well-drained, dark-colored very cobbly loams that have a clay subsoil. Rhyolite is within a depth of 20 inches of the surface. Cave soils are in the lower parts of alluvial fans and valley fill. They are well-drained, light-colored gravelly loams that have a lime-indurated hardpan within a depth of 20 inches of the surface.

This association is used for range. In places areas have been subdivided into small tracts for homesites. The soils are generally not suitable for cultivation, because they are shallow and very shallow.

Descriptions of the Soils

This section describes the soil series and mapping units in the Willcox Area. Each soil series is described in detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile; that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this

profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or there are differences that are apparent in the name of the mapping unit. Color terms are for dry soil unless otherwise stated.

As mentioned in the section, "How This Survey Was Made," not all mapping units are members of a soil series. Torrifluvents, for example, do not belong to a soil series, but nevertheless are listed in alphabetical order along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and range site in which the mapping unit has been placed. The page for the description of each capability unit and range site can be learned by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*10*).[2]

Bernardino Series

The Bernardino series consists of deep, well-drained soils on dissected fans. These soils formed in alluvium derived from acid and basic igneous, sedimentary, and metamorphic rocks. Slopes range from 0 to 10 percent. The vegetation is black, blue, hairy, and side-oats grama, tobosa, three-awn, curly mesquite, fluffgrass, and some scattered mesquite.

In a representative profile the surface layer is reddish-brown and brown gravelly sandy loam about 4½ inches thick. The subsoil is reddish-brown and yellowish-red gravelly clay about 27½ inches thick. The substratum reaches a depth of 60 inches or more. It is light yellowish-brown gravelly sandy clay loam in the upper part and mottled, pink and light-brown sandy clay loam in the lower part. Bernardino soils have a zone of calcium carbonate accumulation at a depth of less than 20 inches.

Permeability is slow. Available water capacity is moderate. The effective rooting depth is 60 inches or more.

These soils are used for range.

Representative profile of Bernardino gravelly sandy loam in an area of Bernardino complex, 0 to 10 percent slopes, 1,800 feet north and 1,700 feet west of the southeast corner of sec. 4, T. 15 S., R. E.; 150 feet east of pipeline:

A11—0 to 2½ inches, reddish-brown (5YR 5/4) gravelly sandy loam, dark reddish brown (5YR 3/4) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; few fine roots; many fine interstitial pores; 25 percent gravel; moderately alkaline; abrupt, smooth boundary.

A12—2½ to 4½ inches, brown (7.5YR 5/4) gravelly sandy loam, dark reddish brown (5YR 3/4) when moist; weak, medium, platy structure parting to weak, fine, subangular blocky and granular; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine roots; common fine and very fine tubular pores; moderately alkaline; abrupt, wavy boundary.

B1t—4½ to 7 inches, reddish-brown (5YR 4/4) gravelly clay loam, dark reddish brown (2.5YR 3/4) when moist; moderate, medium, angular and subangular blocky structure; very hard when dry, friable when

[2] Italic numbers in parentheses refer to Literature Cited, p. 71.

TABLE 1.—*Approximate acreage and proportionate extent of soils*

Soil	Area	Extent
	Acres	*Percent*
Bernardino complex, 0 to 10 percent slopes	569	0.2
Cave gravelly loam	1,784	.5
Cogswell clay loam	7,545	2.1
Cogswell clay loam, alkali	2,724	.7
Cogswell clay	495	.1
Comoro sandy loam, 0 to 2 percent slopes	10,003	2.7
Comoro gravelly sandy loam, 0 to 2 percent slopes	3,634	1.0
Comoro gravelly sandy loam, 5 to 10 percent slopes	542	.2
Comoro sandy loam, alkali variant	694	.2
Cowan sandy loam	4,223	1.2
Crot sandy loam	19,468	5.3
Dry Lake loamy sand	3,323	.9
Duncan loam	5,237	1.4
Duncan loam, shallow variant	720	.2
Elfrida silty clay loam	12,776	3.5
Forrest loam, 0 to 2 percent slopes	11,474	3.1
Forrest gravelly sandy clay loam, 0 to 2 percent slopes	2,734	.8
Forrest gravelly sandy clay loam, 2 to 5 percent slopes	813	.2
Frye sandy loam	5,479	1.5
Gothard fine sandy loam	30,730	8.4
Grabe sandy loam	10,345	2.8
Grabe loam	15,445	4.2
Guest clay loam	11,034	3.0
Guest clay	881	.2
Karro loam	16,143	4.4
Kimbrough gravelly loam, 2 to 25 percent slopes	3,972	1.1
Kimbrough very cobbly loam, shallow over bedrock variant, 15 to 30 percent slopes	1,796	.5
Luzena gravelly clay loam, 5 to 15 percent slopes	733	.2
Luzena very cobbly loam, very cobbly subsoil variant, 15 to 30 percent slopes	2,017	.6
McAllister loam	13,042	3.6
McAllister loam, alkali	1,591	.4
Pima loam	31,305	8.5
Pridham loam	3,087	.8
Sonoita sandy loam, 0 to 2 percent slopes	19,355	5.3
Sonoita sandy loam, 2 to 5 percent slopes	1,616	.4
Sonoita gravelly sandy loam, 0 to 2 percent slopes	786	.2
Stewart loam	7,956	2.2
Torrifluvents	475	.1
Torriorthents, hummocky	5,270	1.4
Tubac sandy loam, 0 to 2 percent slopes	20,215	5.5
Tubac gravelly loam, 10 to 20 percent slopes	378	.1
Tubac sandy clay loam, 0 to 2 percent slopes	33,578	9.1
Vinton loamy sand	4,908	1.3
Playas and lakes	36,502	9.9
Total	367,370	100.0

moist, sticky and plastic when wet; many fine roots; few fine and very fine tubular pores and common exped pores; common thin clay films on faces of peds and in pores; 25 percent gravel; moderately alkaline; clear, wavy boundary.

B2t—7 to 13 inches, yellowish-red (5YR 4/6) gravelly clay, dark red (2.5YR 3/6) when moist; weak, medium, prismatic structure; very hard when dry, firm when moist, sticky and plastic when wet; many fine roots on faces of peds; few fine and very fine tubular pores and common exped pores; common thin clay films on faces of peds and in pores; 25 percent gravel; common, fine and medium, pink (5YR 7/3) and pinkish-white (5YR 8/2), soft masses of lime; strongly effervescent; moderately alkaline; clear, wavy boundary.

B3tca—13 to 32 inches, reddish-brown (5YR 5/4) gravelly clay, reddish brown to yellowish red (5YR 4/4 to 4/6) when moist; weak, medium, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; few fine roots; common fine and very fine tubular pores and few exped pores; common thin clay films on faces of peds and in pores; many, fine and medium, pink (5YR 7/3 and 8/3) segregations of lime, reddish yellow and light reddish brown (5YR 6/6 and 6/4) when moist; strongly to violently effervescent; moderately alkaline; clear, wavy boundary.

C1ca—32 to 40 inches, light yellowish-brown (10YR 6/4) gravelly sandy clay loam, dark yellowish brown (10YR 4/4) when moist; massive; very hard when dry, friable when moist, sticky and plastic when wet; few fine roots; many fine and very fine tubular pores; common, fine and medium, pinkish-white (7.5YR 8/2) veins of lime; violently effervescent; moderately alkaline; clear, wavy boundary.

C2ca—40 to 60 inches, mottled pink and light-brown (7.5 YR 8/4 and 6/4) sandy clay loam that is weakly cemented with lime, pink and brown (7.5YR 7/4 and 5/4) when moist; massive; very hard when dry, friable when moist, sticky and plastic when wet; many fine and very fine and few medium tubular pores; violently effervescent; moderately alkaline.

The A horizon ranges from dark grayish brown to light reddish brown. It is gravelly sandy loam, gravelly sandy clay loam, or gravelly clay loam. The B2t horizon is gravelly clay or gravelly clay loam. Its structure ranges from weak or moderate prismatic to weak or moderate subangular blocky. Depth to a limy horizon ranges from 10 to 20 inches. The C horizon is sandy clay loam, gravelly sandy clay loam, clay loam, gravelly clay loam, sandy loam, or gravelly sandy loam. Reaction is mildly alkaline or moderately alkaline throughout the profile.

Bernardino complex, 0 to 10 percent slopes (BeC).—This complex is about 60 percent Bernardino gravelly sandy loam, 30 percent Bernardino gravelly sandy clay loam, and 10 percent other soils. Nearly level Bernardino gravelly sandy loam is on the top of old lacustrine terrace remnants. Gently sloping to moderately sloping Bernardino gravelly sandy clay loam is on the sides and ends of the terrace remnants. The lower ends of the terraces are 15 to 50 feet above the adjacent flood plain, and the upper ends merge with the valley plain. Flood plains dissect the terraces, forming many, small, separated areas. Fine and medium gravel covers 25 to 40 percent of the surface.

Included with this complex in mapping are areas of Forrest gravelly sandy clay loam, McAllister loam, and Sonoita sandy loam. Forrest gravelly sandy clay loam makes up about 5 percent of the mapped areas, and McAllister loam and Sonoita sandy loam each make up 2 percent. Also included in drainageways are areas of Pima loam and of Guest loam. These soils each make up 1 percent of the mapped areas.

Runoff is slow to medium. The hazard of erosion is slight or moderate.

This complex is used for range. Capability units IIIe–8, irrigated and VIe–1, dryland; Loamy Upland range site.

Cave Series

The Cave series consists of shallow and very shallow, well-drained soils over hardpans. These soils formed in valley fill derived mainly from limestone, but with additions of acid and basic igneous and metamorphic rock. Slopes range from 0 to 5 percent. Elevation is 4,200 to 4,500 feet. The vegetation is creosotebush, tarbush, annual weeds and grasses, and scattered small mesquite and bush muhly.

In a representative profile the surface layer is pinkish-gray and light brownish-gray gravelly loam about 6 inches thick. The upper 5 inches of the underlying material is light brownish-gray gravelly loam. Below this is a white, lime-cemented hardpan that extends to a depth of 25 inches or more. The profile is moderately alkaline.

Permeability is moderate above the hardpan. Available water capacity is very low. The effective rooting depth is 4 to 20 inches.

These soils are used as range and wildlife habitat.

Representative profile of Cave gravelly loam, 2,000 feet north of the southwest corner of sec. 18, T. 15 S., R. 24 E.; 9 miles south and 6 miles east of Willcox:

A11—0 to 1 inch, pinkish-gray (7.5YR 6/2) gravelly loam, brown (10YR 4/3) when moist; weak, thin, platy structure parting to weak, fine, granular; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; few fine roots; common very fine and fine tubular pores; few fine vesicular pores; 25 percent angular limestone gravel, ½ inch to 1½ inches in size; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

A12—1 to 6 inches, light brownish-gray (10YR 6/2) gravelly loam, brown (10YR 4/3) when moist; weak, very fine and fine, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; few fine roots; common very fine and fine tubular pores; 20 percent hardpan fragments, ½ inch to 3 inches in size; violently effervescent; moderately alkaline; clear, wavy boundary.

C1ca—6 to 11 inches, light brownish-gray (10YR 6/2) gravelly loam, brown (10YR 4/3) when moist; weak, very fine and fine, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; few fine roots; few very fine and fine tubular pores; 25 percent hardpan fragments, ½ inch to 3 inches in size; violently effervescent; moderately alkaline; abrupt, wavy boundary.

C2cam—11 to 25 inches, white (N 8/0), gravelly lime-cemented hardpan, pinkish white (7.5YR 8/2) when moist; hardpan has a thin, laminar upper layer; massive; extremely hard when dry, extremely firm when moist; violently effervescent; moderately alkaline.

The A horizon is dominantly gravelly loam but ranges to gravelly sandy loam. It is dark grayish brown to very pale brown or pinkish gray. The Cca horizon ranges from gravelly loam to gravelly sandy loam. The lime-cemented hardpan is at a depth of 4 to 20 inches. In places several lime-cemented hardpans are separated by material that is only weakly cemented with lime.

Cave gravelly loam (Ca).—This soil is on low foothills

and fans. Slopes range from 0 to 5 percent but are dominantly 2 to 3 percent. Areas are oval or crescent-shaped and are about 75 to 100 acres in size.

Included with this soil in mapping are areas of Elfrida soils that have a surface layer of loam, areas of Karro loam at the lower edges of slopes, and narrow areas of Grabe loam in swales. Also included are scattered areas of a soil that is similar to this Cave soil but is moderately deep over a hardpan. The included soils make up 20 percent of the mapped areas.

Runoff is medium. The hazard of erosion is slight.

This soil is used as range and wildlife habitat. Capability unit VIIs–1, dryland; Caliche Upland range site.

Cogswell Series

The Cogswell series consists of deep, well-drained soils in broad swales or on valley plains and old lake margins. These soils formed in mixed alluvium derived from acid and basic igneous rocks and sedimentary rocks. Slopes are 0 to 2 percent. Elevation is 4,100 to 4,400 feet. The vegetation is tobosa, alkali sacaton, and mesquite.

In a representative profile the surface layer is brown clay loam about 12 inches thick. The underlying material is brown clay about 14 inches thick. The upper part of the substratum is light-brown clay loam about 20 inches thick. Below this is mottled, strong-brown, reddish-yellow, and white clay loam to a depth of 60 inches or more. The profile is moderately alkaline.

Permeability is slow. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops, as range, and for homesites.

Representative profile of Cogswell clay loam, 500 feet south and 300 feet east of the northwest corner of sec. 4, T. 13 S., R. 24 E.:

Ap—0 to 12 inches, brown (10YR 5/3) clay loam, dark brown (10YR 3/3) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist, slightly sticky and plastic when wet; common fine roots; common fine and medium tubular pores; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

A12—12 to 26 inches, brown (10YR 5/3) clay, dark brown (10YR 3/3) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common fine roots; common fine interstitial and tubular pores; strongly effervescent; moderately alkaline; clear, wavy boundary.

Cca—26 to 46 inches, light-brown (7.5YR 6/4) clay loam, dark brown (7.5YR 4/4) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; common to many fine interstitial pores and few fine tubular pores; many, fine and medium, very pale brown (10YR 8/3), light yellowish-brown (10YR 6/4), and light brownish-gray (10YR 6/2), soft masses and filaments of lime; common to many, angular, hard fragments of lime that range up to about ½ to 1 inch in diameter; violently effervescent; moderately alkaline; clear, wavy boundary.

B2tcab—46 to 60 inches, mottled, strong-brown (7.5YR 5/6), reddish-brown (7.5YR 6/6), and white (N 8/0) clay loam, strong brown (7.5YR 5/6) and light gray (N 7/0) when moist; moderate, fine and medium, prismatic structure; hard when dry, friable when moist, slightly sticky and plastic when wet; common fine interstitial pores; common thin clay films on faces of peds; many, medium and large, white (10YR 8/2) and light-gray (10YR 7/2), soft masses and filaments of lime; violently effervescent; moderately alkaline.

The Ap and A1 horizons range from very dark grayish brown to brown. They are clay and clay loam and are mildly alkaline to very strong alkaline and slightly effervescent to strongly effervescent. The Cca horizon ranges from heavy clay loam to clay. It is moderately alkaline to strongly alkaline and strongly effervescent to violently effervescent. In places the upper part of the Cca horizon has a thin, discontinuous, platy layer that is weakly cemented with lime. Depth to the Cca horizon ranges from 18 to 39 inches. The buried B2t horizon is absent in places.

Cogswell clay loam (Cc).—This soil is nearly level to level. It is in swales and along old lake margins north of Willcox in the Stewart District and at the south end of the Willcox Playa. Areas are long and narrow to somewhat broad and are about 75 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small scattered areas of Cogswell clay loam, strongly saline-alkali, that are shown on the soil map by a spot symbol. Also included are areas of Guest clay loam and Guest clay in swales, areas of Pima loam, and areas of Gothard loam near the lake margin. The included soils make up about 10 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops, as range, and for homesites. It is a potential source of sand and gravel. Capability units IIIs–8, irrigated, VIIs–1, dryland; Saline Bottom range site.

Cogswell clay loam, alkali (Ce).—This soil is nearly level to level. It is in swales and along old lake margins north of Willcox in the Stewart District and at the south end of the Willcox Playa. Areas are about 90 to 100 acres in size and are generally oval and elongated. The profile of this soil is similar to the one described as representative of the series, but it is strongly alkaline to very strongly alkaline throughout.

Included with this soil in mapping are small, scattered areas of Guest clay loam and Guest clay, areas of Gothard loam near the lake margin, and nonalkali areas of Pima loam in small narrow bands. The included soils make up about 15 percent of the mapped areas.

Runoff is slow. The hazard of erosion is slight. Because of the salt and alkali content, the available water capacity is moderate.

This soil is used for irrigated crops, as range, and for homesites. It is a potential source of sand and gravel. Capability units IIIs–9, irrigated, VIIs–1, dryland; Saline Bottom range site.

Cogswell clay (Cg).—This nearly level to level soil is in swales and along old lake margins north of Willcox in the Stewart District and at the south end of the Willcox Playa. Areas are usually long and somewhat broad and are about 150 acres in size.

Included with this soil in mapping are small, scattered areas of Cogswell clay loam, alkali, and areas of Guest clay, Guest clay loam, Pima loam, and Gothard loam. The included soils make up about 15 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops, as range, and for homesites. It is a potential source of sand and gravel. Capability units IIIs–3, irrigated, VIIs–1, dryland; Saline Bottom range site.

Comoro Series

The Comoro series consists of deep, well-drained soils on flood plains and low terraces. These soils formed in mixed alluvium derived from acid and basic igneous, metamorphic, and sedimentary rocks. Slopes range from 0 to 10 percent. Elevation is 4,200 to 4,600 feet. The vegetation is burroweed, three-awn, sand dropseed, blue grama, bush muhly, yucca, mesquite, catclaw, and annual grasses.

In a representative profile the surface layer is brown sandy loam and gravelly sandy loam about 37 inches thick. The underlying material is very pale brown fine gravelly loamy sand to a depth of 60 inches or more. The profile is moderately alkaline throughout.

Permeability is moderately rapid. Available water capacity is moderate or low. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops, as range, and for homesites and other community developments. They are a possible source of sand and gravel.

Representative profile of Comoro sandy loam, 0 to 2 percent slopes, 2,000 feet west and 1,150 feet north of the southeast corner of sec. 25, T. 17 S., R. 24 E.:

A11—0 to 3 inches, brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many fine and medium roots; few fine tubular pores; slightly effervescent; moderately alkaline; clear, smooth boundary.

A12—3 to 25 inches, brown (10YR 5/3) sandy loam, very dark grayish brown (10YR 3/3) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; few fine and medium roots; few fine tubular pores; slightly effervescent; moderately alkaline; clear, smooth boundary.

A13—25 to 37 inches, brown (10YR 5/3) fine gravelly sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; 20 percent fine (2–3 millimeters) gravel; slightly effervescent; moderately alkaline; clear, smooth boundary.

C—37 to 60 inches, very pale brown (10YR 7/3) fine gravelly loamy sand and fine sand, brown (10YR 5/3) when moist; single grained; loose when dry or moist; 15 percent fine (2–3 millimeters) gravel; slightly effervescent; moderately alkaline.

The A horizon ranges from very dark gray to brown. It is sandy loam, gravelly sandy loam, fine sandy loam, loam, or gravelly loam. Thin strata, which are less than 3 inches thick and are gravelly in places, of silt loam to fine sand occur throughout this horizon. The A horizon ranges from neutral to moderately alkaline and from noneffervescent to strongly effervescent. The C horizon is sandy loam, gravelly sandy loam, and gravelly loamy sand that has thin strata of loam, very fine sandy loam, and fine sandy loam. It is mildly alkaline to moderately alkaline and slightly effervescent to strongly effervescent. Filaments of lime are common in places.

Comoro sandy loam, 0 to 2 percent slopes (CmA).—This soil is on long, narrow, slightly elevated ridges. It occurs in all parts of the survey area but is mainly in the Sunizona, Sunsites, and northern Stewart District areas. Slopes are dominantly 0.5 to 1.5 percent. Areas are about 100 acres in size.

Included with this soil in mapping are areas of Comoro gravelly sandy loam, 0 to 2 percent slopes; scattered areas of Grabe sandy loam; areas of Tubac sandy loam and Forrest sandy loam; and areas of Sonoita sandy loam on scattered rounded ridges. The included soils make up about 25 percent of the mapped areas.

Runoff is very slow. Available water capacity is moderate. The hazard of water erosion is slight, and the hazard of soil blowing is moderate.

This soil is used for irrigated crops, as range, and for homesites and other community developments. Capability units IIs–7, irrigated, VIs–1, dryland; Sand Upland range site.

Comoro gravelly sandy loam, 0 to 2 percent slopes (CnA).—This soil is on long, narrow, slightly elevated ridges in all parts of the survey area but is mainly in the Sunizona, Sunsites, and eastern Kansas Settlement areas. Slopes are dominantly 0.5 to 1.5 percent. Areas are about 75 to 80 acres in size. This soil has a profile similar to the one described as representative of the series, but it has a gravelly surface layer and low available water capacity.

Included with this soil in mapping are scattered areas of Comoro sandy loam; areas, west of Pearce, of Comoro gravelly loamy sand; areas of Grabe sandy loam in long, narrow strips along the lower part of ridges and in shallow swales; and areas of Tubac sandy loam. The included soils make up about 20 percent of the mapped areas.

Runoff is very slow. The hazard of erosion is slight. The hazard of soil blowing is moderate.

This soil is used for irrigated crops, as range, and for homesites and other community developments. Capability units IIIs–7, irrigated, VIs–1, dryland; Sand Upland range site.

Comoro gravelly sandy loam, 5 to 10 percent slopes (CnC).—This soil is on a nearly continuous, long, narrow, beachlike ridgefront along the western side of the Willcox Playa. It has a profile similar to the one described as representative of the series, but it is gravelly throughout and is slightly coarser.

Included with this soil in mapping are small areas of Elfrida loam and Comoro gravelly sandy loam, 0 to 2 percent slopes, on the upper part of the ridge; areas of Karro loam, on the upper and lower parts of the ridge; and areas of Crot loam, in long, narrow bands on foot slopes. The included soils make up 20 percent of the mapped areas.

Runoff is medium, and the erosion hazard is moderate. Available water capacity is low.

This soil is used as range and is a source of gravel and sand. Capability units IIIe–7, irrigated, VIe–1, dryland; Sand Upland range site.

Comoro Variant

The Comoro variant consists of deep, moderately well-drained soils on flood plains and low terraces. These soils formed in alluvium derived from acid and basic igneous and sedimentary rocks. The alluvium is over old, saline-alkali, lacustrine sediment. Slopes are 0 to 2 percent. The vegetation is yucca, sand dropseed, fluffgrass, and annual grasses.

In a representative profile the surface layer is grayish-brown and dark grayish-brown sandy loam about 22 inches thick. The underlying material is very pale brown sandy loam about 14 inches thick. It lies un-

conformably over mottled, pale-olive and white clay loam about 13 inches thick. Below this is light-gray and very pale brown very gravelly sand to a depth of 60 inches or more. The profile is moderately alkaline in the upper 10 inches but very strongly alkaline below.

Permeability is slow. Available water capacity is moderate. The effective rooting depth is 60 inches or more.

These soils are used as range and for homesites and other community developments.

Representative profile of Comoro sandy loam, alkali variant, 1,450 feet south and 100 feet east of the northeast corner of sec. 11, T. 14 S., R. 24 E.; 2½ miles southwest of Willcox on State Highway 86:

A11—0 to 10 inches, grayish-brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common fine and medium roots; few very fine tubular pores; moderately alkaline; clear, smooth boundary.

A12—10 to 22 inches, grayish-brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and nonplastic when wet; few fine roots; few very fine tubular pores; strongly effervescent; very strongly alkaline; gradual, smooth boundary.

C1—22 to 36 inches, very pale brown (10YR 7/3) light sandy loam, dark brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; very few very fine tubular pores; strongly effervescent; very strongly alkaline; clear, wavy boundary.

IIC2ca—36 to 49 inches, mottled, pale-olive (5Y 6/3) and white (5Y 8/1) light clay loam, olive (5Y 5/3) and pale yellow (5Y 7/3) when moist; massive; hard when dry, friable when moist, very sticky and very plastic when wet; violently effervescent; few (5–10 millimeters in size) extremely hard concretions of lime; very strongly alkaline; abrupt, smooth boundary.

IIIC3g—49 to 66 inches, light-gray (2.5Y 7/2) very gravelly sand, grayish brown (2.5Y 5/2) when moist; single grained; loose when dry or moist; approximately 50 percent fine gravel less than ½ inch in diameter; strongly effervescent; very strongly alkaline; clear, smooth boundary.

IIIC4—66 to 72 inches, very pale brown (10YR 7/3) very gravelly sand, yellowish brown (10YR 5/4) when moist; single grained; loose when dry or moist; approximately 35 percent gravel 2½ inches in diameter; strongly effervescent; moderately alkaline.

The A horizon ranges from dark grayish brown to brown. It is sandy loam or fine sandy loam that is mildly alkaline to moderately alkaline in the upper part and moderately alkaline to very strongly alkaline in the lower part. Effervescence is none to strong. The C1 horizon is light sandy loam, sandy loam, or fine sandy loam. It ranges from moderately alkaline to very strongly alkaline and is slightly effervescent to strongly effervescent. Depth to the Cca horizon ranges from 18 to 40 inches. The Cca horizon is strongly alkaline or very strongly alkaline. The unconformable material is dominantly coarse textured. It is stratified and ranges from very gravelly or nongravelly coarse sand to clay loam. The latter is less than 2 inches thick, except where it overlies sandy material. Reaction is strongly alkaline to very strongly alkaline.

Comoro sandy loam, alkali variant (Co).—This soil occurs on long, narrow, slightly elevated ridges in areas of Crot, Gothard, and Stewart soils along the edges of the old lakebed. It is mainly in the vicinity of Willcox. Areas are about 10 acres in size. Slopes are dominantly 0.5 to 1 percent.

Included with this soil in mapping are small pockets of Comoro sandy loam and small bands of Crot sandy loam, Gothard sandy loam and loam, and Stewart sandy loam and loam on the lower part of foot slopes.

Runoff is medium. The hazard of water erosion is slight, and the hazard of soil blowing is moderate.

This soil is used as range and is a potential source of sand and gravel. Capability unit VIIe–1, dryland; Sand Upland range site.

Cowan Series

The Cowan series consists of deep, well-drained soils on flood plains and low terraces. These soils formed in alluvium. Slopes are 0 to 2 percent. Elevation is 4,200 to 4,500 feet. The vegetation is blue grama, Rothrock grama, yucca, scattered mesquite, and annual grasses.

In a representative profile the surface layer is brown sandy loam about 2 inches thick. The underlying material is reddish-brown and brown loamy sand and sandy loam to a depth of 60 inches. The profile is neutral to moderately alkaline.

Permeability is moderately rapid. Available water capacity is moderate. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops and as range.

Representative profile of Cowan sandy loam, 400 feet east and 25 feet north of the south quarter corner of sec. 35, T. 11 S., R. 23 E.:

A1—0 to 2 inches, brown (7.5YR 5/4) sandy loam, dark reddish brown (5YR 3/4) when moist; single grained; loose when dry or moist; many fine, medium, and coarse roots; common very fine interstitial pores; neutral; clear, smooth boundary.

C1—2 to 23 inches, reddish-brown (5YR 4/4) light sandy loam, dark reddish brown (5YR 3/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many fine, medium, and coarse roots; many fine interstitial pores and common very fine tubular pores; neutral; abrupt, wavy boundary.

C2—23 to 45 inches, reddish-brown (5YR 5/4) loamy sand, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; few fine and medium roots; many fine and medium interstitial pores; few fine gravel; moderately alkaline; gradual, wavy boundary.

C3—45 to 56 inches, brown (7.5YR 5/4) loamy sand, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; few coarse roots; many fine and medium interstitial and tubular pores; few fine gravel; mildly alkaline.

The profile is stratified loamy sand, light sandy loam, sandy loam, and loamy coarse sand that contains some thin strata, less than 3 inches thick, of silt loam or coarse sand. It is as much as 15 percent gravel. The A horizon ranges from light sandy loam to loamy sand. In places, thin, discontinuous strata that are weakly cemented with silica are below a depth of 48 inches.

Cowan sandy loam (Cs).—This nearly level soil is on narrow, meandering, slightly elevated old flood plains and low terraces, mainly in the northern part of the survey area. Most areas are about 20 to 25 acres in size.

Included with this soil in mapping are areas where the surface layer is loamy sand or loamy fine sand and areas of Cowan sandy loam, 2 to 4 percent slopes on short side slopes or narrow escarpments. Also included are scattered areas of Sonoita sandy loam and areas of

Tubac sandy loam and Comoro sandy loam. The included soils make up 15 percent of the mapped areas. Small coppice dunes are in small unprotected areas.

Runoff is very slow, and the hazard of water erosion is slight. The hazard of soil blowing is generally moderate, but it is severe in some small areas.

This soil is used for irrigated crops and as range. Capability units IIIs–7, irrigated, VIe–1, dryland; Sand Upland range site.

Crot Series

The Crot series consists of deep, somewhat poorly drained, saline-alkali affected soils on low lake terraces adjacent to playas. These soils formed in alluvium derived from mixed sources, dominantly acid and basic igneous rocks. Slopes are 0 to 1 percent, but in places the surface has uneven microrelief because of soil blowing. Elevation is 4,136 to 4,200 feet. The vegetation is alkali sacaton, inland saltgrass, tobosa, saltbush, scattered mesquite, and annual grasses.

In a representative profile the surface layer is light brownish-gray sandy loam about 5 inches thick. The subsoil is brown and mottled, light-gray and yellowish-brown sandy clay loam about 15 inches thick. The substratum, to a depth of 60 inches, is light-gray, olive, and pale-yellow, finely stratified sand to silt loam. The profile is strongly alkaline to very strongly alkaline.

Permeability is very slow. Available water capacity is moderate. The effective rooting depth is 60 inches or more. A seasonal high water table is at a depth of 3 to 5 feet.

These soils are used as range and for homesites and other community developments.

Representative profile of Crot sandy loam, 400 feet south and 2,250 feet east of the northwest corner of sec. 23, T. 14 S., R. 24 E.:

A11—0 to 2 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; moderate, thick, platy structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many fine and medium roots and few coarse roots; common very fine and fine vesicular and interstitial pores; slightly effervescent; strongly alkaline; abrupt, smooth boundary.

A12—2 to 5 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common fine and medium roots and few coarse roots; common fine tubular pores; slightly effervescent; moderately alkaline; abrupt, smooth boundary.

B21tca—5 to 11 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) when moist; moderate, medium and coarse, columnar structure; hard when dry, friable when moist, sticky and plastic when wet; common fine roots and few coarse roots; common fine tubular pores; common thin clay films on faces of peds and in pores; common, fine and medium, white (10YR 8/2), soft masses of lime; strongly effervescent; very strongly alkaline; clear, wavy boundary.

B22tca—11 to 17 inches, mottled, light-gray (2.5Y 7/2) and yellowish-brown (10YR 5/4) sandy clay loam, grayish brown (2.5YR 5/2) and dark yellowish brown (10YR 4/4) when moist; moderate, medium, prismatic structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine, fine, and coarse roots; many fine and very fine tubular pores; few thin clay films on faces of peds and in pores; common, fine and medium, white (10YR 8/2), soft masses of lime; strongly effervescent; very strongly alkaline; clear, wavy boundary.

B3ca—17 to 20 inches, light-gray (2.5Y 7/2) coarse sandy loam, grayish brown (2.5Y 5/2) when moist; few, medium, faint, light yellowish-brown (10YR 6/4) iron mottles, yellowish brown (10YR 5/4) when moist; weak, coarse, prismatic structure; hard when dry, friable when moist, slightly sticky and nonplastic when wet; few coarse roots; common very fine and fine tubular pores; few thin clay films in root channels; strongly effervescent; very strongly alkaline; abrupt, wavy boundary.

C1ca—20 to 33 inches, light-gray (5Y 7/2) coarse sandy loam, olive (5Y 5/3) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; few coarse roots; few fine tubular pores; few fine pebbles strongly effervescent; very strongly alkaline; abrupt, wavy boundary.

C2ca—33 to 60 inches, light-gray (5Y 7/2), pale-yellow (5Y 7/3), and olive-gray (5Y 5/2), stratified sand, loamy sand, sandy loam, very fine sandy loam, loam, and silt loam (strata are ½ inch to 4 inches thick), olive gray (5Y 4/2 and 5/2) and olive (5Y 5/3) when moist; massive; slightly hard to hard when dry, friable when moist; nonsticky to slightly sticky and nonplastic to slightly plastic when wet; few coarse roots; common very fine interstitial and tubular pores; strongly effervescent; very strongly alkaline.

The A1 horizon ranges from gray to light brownish-gray. It is moderately alkaline to very strongly alkaline. The B2t horizon is clay loam, sandy clay loam, and heavy loam and is strongly alkaline to very strongly alkaline. The C horizon is finely stratified and ranges from clay to gravelly sand. It is strongly alkaline to very strongly alkaline. The limy horizon is at a depth of 5 to 30 inches. In places a buried Bt horizon is at a depth of 36 inches or more.

Crot sandy loam (Ct).—This level to nearly level soil is on alkali flats, mainly in the area immediately adjoining the Willcox Playa. Areas are irregular in shape and are about 150 acres in size.

Included with this soil in mapping are scattered areas of Crot loam in slight depressions; scattered areas of Stewart sandy loam and loam; small, scattered areas of Gothard fine sandy loam; areas where the surface layer is loamy sand; and areas of Comoro sandy loam and Comoro sandy loam, alkali variant, on narrow ridges. Also included are areas where slopes are 2 to 5 percent; small, actively eroding areas; and mounds and escarpments of sandy soils on the leeward side of small playas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used as range and for homesites and other community developments. Capability unit VIIw–1, dryland; Saline Bottom range site.

Dry Lake Series

The Dry Lake series consists of deep, moderately well drained soils on low terraces. These soils formed in mixed alluvial and lacustrine sediment derived from acid and basic igneous rock and some sedimentary rock. Slopes are 0 to 2 percent. Elevation is 4,170 to 4,300 feet. The vegetation is alkali sacaton, scattered mesquite, and annual grasses.

In a representative profile the surface layer is grayish-brown loamy sand about 9 inches thick. The upper part of the substratum is grayish-brown loamy sand 15 inches thick. Below this is unconformable, white and very pale brown heavy loam that extends to

a depth of 60 inches or more. The profile is moderately alkaline in the upper 24 inches and strongly alkaline below.

Permeability is slow. Available water capacity is moderate. The effective rooting depth is 60 inches or more.

These soils are used as range and for irrigated crops.

Representative profile of Dry Lake loamy sand, 350 feet south and 250 feet east of the northwest corner of sec. 10, T. 16 S., R. 25 E.:
(See laboratory data)

Ap—0 to 9 inches, grayish-brown (10YR 5/2) loamy sand, very dark grayish brown (10YR 3/2) when moist; single grained; loose when dry or moist; common fine and very fine roots; many fine interstitial pores and few fine tubular pores; strongly effervescent; few, fine, white (10YR 8/2), hard nodules of lime; moderately alkaline; abrupt, smooth boundary.

C1—9 to 24 inches, grayish-brown (10YR 5/2) loamy sand, very dark grayish brown (10YR 3/2) when moist; single grained; loose when dry or moist; common fine and very fine roots and few medium roots; few very fine tubular pores; strongly effervescent; common, fine, white (10YR 8/2), hard nodules of lime; moderately alkaline; clear, irregular boundary.

IIC2ca—24 to 35 inches, white (10YR 8/2) and very pale brown (10YR 7/3) heavy loam, very pale brown (10YR 7/3) and brown (10YR 5/3) when moist; massive; very hard when dry, friable when moist, sticky and plastic when wet; many very fine and fine roots; few fine tubular pores; violently effervescent; strongly alkaline; gradual, wavy boundary.

IIC3ca—35 to 60 inches, white (10YR 8/2) heavy loam, very pale brown (10YR 7/3) when moist; massive; very hard when dry, friable when moist, sticky and plastic when wet; few very fine and fine roots; few very fine and fine tubular pores; violently effervescent; strongly alkaline.

The A horizon ranges from grayish brown to light yellowish brown. It is sand or loamy sand. Depth of the Cca horizon ranges from 16 to 32 inches, but it is dominantly about 22 inches. The Cca horizon is heavy loam, sandy clay loam, or clay loam. In places the IICca horizon is marly material weakly cemented with lime. It is strongly alkaline to very strongly alkaline.

Dry Lake loamy sand (Dr).—This soil is mainly in the Kansas Settlement on the southeast side of the Willcox Playa, but some areas are northeast of Willcox. Slopes range from 0 to 2 percent but are dominantly about 0.2 to 1 percent. Areas range from 5 to 400 acres in size but are dominantly in large ovals of about 80 to 100 acres.

Included with this soil in mapping are areas where the surface layer is fine sand, areas of Crot sandy loam and Gothard sandy loam in low positions, areas of Karro sandy loam, and areas of Vinton loamy sand on small dunes. The included soils make up 20 percent of the mapped areas.

Runoff is very slow, and the hazard of water erosion is slight. The hazard of soil blowing is moderate to high.

This soil is used as range and for irrigated crops. Capability units IIIe–8, irrigated, VIe–1, dryland; Sand Upland range site.

Duncan Series

The Duncan series consists of moderately deep, well-drained, saline-alkali affected soils on alkali flats that border playas. These soils formed in mixed lacustrine and alluvial sediment derived mainly from acid and basic igneous rocks and limestone. Slopes are 0 to 1 percent, but in places the surface has uneven microrelief because of soil blowing. Elevation is 4,137 to 4,200 feet. The vegetation is alkali sacaton, saltgrass, tobosa, saltbush, scattered mesquite, and annual grasses.

In a representative profile the surface layer is light-gray loam about 5 inches thick. The subsoil is light-brown, brown, and pinkish-gray clay about 30 inches thick. The next layer is very pale brown silica- and lime-cemented hardpan about 5 inches thick. Below this is mostly reddish-brown and pinkish-white gravelly clay loam and clay loam that extends to a depth of 60 inches or more. The profile is strongly alkaline to very strongly alkaline.

Permeability is very slow above the hardpan. Available water capacity is low. The effective rooting depth is 20 to 40 inches.

These soils are used as range and for homesites and other community developments.

Representative profile of Duncan loam, 100 feet north and 220 feet west of the southwest corner of sec. 23, T. 13 S., R. 24 E.:

A11—0 to 2 inches, light-gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) when moist; weak, thick, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots; common fine, medium, and coarse vesicular and tubular pores; slightly effervescent; strongly alkaline; abrupt, smooth boundary.

A12—2 to 5 inches, light-gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots; common very fine, fine, and medium vesicular pores and few tubular pores; slightly effervescent; strongly alkaline; abrupt, smooth boundary.

B21t—5 to 11 inches, brown (10YR 5/3) clay, dark brown (10YR 3/3) when moist; moderate, medium, prismatic structure parting to strong, medium and coarse, angular and subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; many fine and medium roots and few coarse roots; common moderately thick clay films on faces of peds; slightly effervescent; few, fine, white (10YR 8/2), soft masses of lime; very strongly alkaline; clear, wavy boundary.

B22t—11 to 19 inches, light-brown (7.5YR 6/4) clay, dark brown (7.5YR 4/4) when moist; moderate, medium, prismatic structure; hard when dry, friable when moist, sticky and plastic when wet; many fine and medium roots and few coarse roots; few fine tubular pores; common thin clay films on faces of peds; few, fine, white (10YR 8/2), soft masses of lime; strongly effervescent; very strongly alkaline; clear, wavy boundary.

B23t—19 to 31 inches, pinkish-gray (7.5YR 7/2) clay, brown (7.5YR 5/4) when moist; moderate, fine, subangular blocky structure; very hard when dry, friable when moist, sticky and very plastic when wet; common fine and medium roots and few coarse roots; few very fine tubular pores; common thin clay films on faces of peds; few, fine, white (10YR 8/2), soft masses of lime; strongly effervescent; very strongly alkaline; clear, wavy boundary.

B3tca—31 to 35 inches, pinkish-brown (7.5YR 7/2) clay, brown (7.5YR 5/4) when moist; moderate, fine and medium, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; few medium roots; common

very fine tubular pores; few thin clay films on faces of peds; many, medium and large, white (10YR 8/2), soft masses of lime; violently effervescent; very strongly alkaline; abrupt, smooth boundary.

Csicam—35 to 40 inches, very pale brown (10YR 7/3) and light yellowish-brown (10YR 6/4) duripan, yellowish brown (10YR 5/4) and brown (7.5YR 5/4) when moist; massive; extremely hard when dry or moist; few fine and coarse roots in fractures; violently effervescent; very strongly alkaline; clear, smooth boundary.

B21tsicab—40 to 46 inches, mottled, reddish-brown (5YR 5/4) and pinkish-white (7.5YR 8/2) gravelly clay loam, reddish brown (5YR 4/4) and light brown (7.5YR 6/4) when moist; moderate, medium, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; few fine tubular pores; common thin clay films on faces of peds; common hard durinodes; many, medium and large, pinkish-white (7.5YR 8/2), soft masses of lime; strongly effervescent; very strongly alkaline; clear, wavy boundary.

B22tsab—46 to 60 inches, reddish-brown (5YR 5/4) clay loam, reddish brown (5YR 4/4) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine tubular pores; common thin clay films on faces of peds and in pores; few, fine, pinkish-white (7.5YR 8/2) masses of lime and salt crystals; slightly effervescent; moderately alkaline.

The A1 horizon ranges from light gray to very pale brown. It is sandy loam, fine sandy loam, silt loam, loam, or clay loam in plowed areas. It is effervescent or noneffervescent and strongly alkaline to very strongly alkaline. Depth to the Csicam horizon (duripan) ranges from 20 to 40 inches but is generally 30 to 36 inches. The horizons below the hardpan are variable and range from weakly cemented material to mottled lacustrine material.

Duncan loam (Du).—This nearly level soil is on alkali flats that border the Willcox Playa. Slopes are dominantly 0.1 to 0.5 percent. Areas are irregular in shape. They range from 10 to 300 acres in size but are generally about 65 acres.

Included with this soil in mapping are small areas of Gothard loam and Crot loam; small, narrow bands of Karro loam, especially near Cochise and just north of Willcox; and small areas of Stewart loam. Also included are areas of Comoro sandy loam and Comoro sandy loam, alkali variant, in long, narrow strips and on small, rounded, oval ridges. These soils are shown on the soil map by sand symbols in areas as large as 5 acres. Small, rounded saline spots also occur in places. The included soils make up 10 percent of the mapped areas.

Runoff is very slow, and the hazard of erosion is slight.

The soil is used as range, for homesites and other community developments, and for road fill. Capability unit VIIs-1, dryland; Saline Bottom range site.

Duncan Variant

The Duncan variant consists of shallow and very shallow, somewhat poorly drained, saline-alkali affected soils over a hardpan. The soils are on nearly level low terraces and alkali flats that border large playas. They formed in lacustrine and alluvial sediment derived from mixed sources that include acid and basic igneous rocks and metamorphic rock. Slopes are 0 to 1 percent. Elevation is 4,137 to 4,200 feet. The vegetation is alkali sacaton, inland saltgrass, alkali lovegrass, scattered mesquite, and annual grasses and weeds.

In a representative profile the surface layer is brown loam about 3 inches thick. The subsoil is brown and light-brown clay about 10 inches thick. The next layer is a silica- and lime-cemented hardpan about 10 inches thick. Below the hardpan is buried, light-gray clay about 5 inches thick. Below this is stratified, light-gray sandy clay loam to very fine sandy loam that extends to a depth of 60 inches or more. The profile is strongly alkaline and very strongly alkaline.

Permeability is slow above the hardpan. Available water capacity is very low. The effective rooting depth is 4 to 20 inches.

These soils are used as range and for homesites and other community developments.

Representative profile of Duncan loam, shallow variant, 1,500 feet north and 1,950 feet east of the southwest corner of sec. 29, T. 13 S., R. 25 E.; 1/4 mile northeast of Willcox on State Highway 86:

A1—0 to 3 inches, brown (10YR 5/3) loam, dark brown (10YR 4/3) when moist; weak, medium and thick, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine roots; common very fine pores; slightly effervescent; strongly alkaline; abrupt, smooth boundary.

B21t—3 to 8 inches, brown (7.5YR 5/4) clay, reddish brown (5YR 4/4) when moist; weak, medium, prismatic structure parting to moderate, fine and medium, angular and subangular blocky; very hard when dry, firm when moist, very sticky and very plastic when wet; very few very fine roots; many moderately thick clay films on faces of peds; few, fine, white (10YR 8/2), soft masses of lime; very strongly effervescent; very strongly alkaline; clear, smooth boundary.

B22t—8 to 13 inches, light-brown (7.5YR 6/4) heavy loam, dark brown (7.5YR 4/4) when moist; weak, medium and coarse, subangular blocky structure; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine roots; few fine tubular pores; few thin clay films on faces of peds; strongly effervescent; very strongly alkaline; abrupt, smooth boundary.

C1sicam—13 to 23 inches, brown (7.5YR 4/2) hardpan, dark brown (7.5YR 3/2) when moist; massive; extremely hard when dry, extremely firm when moist; many fine and very fine interstitial pores with yellowish-red (5YR 4/8) coatings or stains below a 1/4-inch thick, dense, laminar cap; strongly effervescent; very strongly alkaline; abrupt, smooth boundary.

B2tb—23 to 28 inches, light-gray (5Y 7/2) clay, dark grayish brown (2.5Y 4/2) when moist; common, fine, faint, light-gray (5Y 7/1) and gray (5Y 5/1) mottles; moderate to strong, medium to coarse, prismatic structure; very hard when dry, very firm when moist, sticky and plastic when wet; few fine and very fine tubular pores; many moderately thick clay films on faces of peds; strongly effervescent; very strongly alkaline; clear, smooth boundary.

C2cab—28 to 48 inches, light-gray (2.5Y 7/2) sandy clay loam, grayish brown (2.5Y 5/2) when moist; massive; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine tubular pores; many, medium and large, white (N 8/0), soft masses of lime; violently effervescent; very strongly alkaline; clear, smooth boundary.

C3b—48 to 68 inches, light-gray (2.5Y 7/2) very fine sandy loam, grayish brown (2.5Y 5/2) when moist; massive; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few

very fine interstitial pores; slightly effervescent; very strongly alkaline.

The A horizon ranges from gray to very pale brown. It is fine sandy loam, loam, and silt loam and is strongly alkaline to very strongly alkaline. The B2t horizon is clay or heavy clay and is strongly alkaline to very strongly alkaline. Depth to the C1sicam horizon ranges from 4 to 20 inches. The buried soil is alkaline to very strongly alkaline.

Duncan loam, shallow variant (Dv).—This soil is in the vicinity of Willcox. Slopes are dominantly less than 0.5 percent. Areas are about 20 acres in size and oval or round in shape.

Included with this soil in mapping are areas of Stewart loam on slightly higher positions and small, long, narrow areas of Gothard fine sandy loam and Crot loam. The included soils make up 10 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used as range and for homesites and other community developments. Capability unit VIIw–1, dryland; Saline Bottom range site.

Elfrida Series

The Elfrida series consists of deep, well-drained soils on flood plains and valley plains near old lake margins. These soils formed in mixed alluvium derived from acid and basic igneous rocks and some limestone. Slopes are 0 to 2 percent. Elevation is 4,137 to 4,300 feet. The vegetation is creosotebush, tobosa, fluffgrass, alkali sacaton, gramas, mesquite, and annual weeds and grasses.

In a representative profile the surface layer is grayish-brown and brown silty clay loam about 22 inches thick. The underlying material is pinkish-gray, pinkish-white, and pink clay loam and heavy loam that extends to a depth of 60 inches or more. The profile is moderately alkaline.

Permeability is moderately slow. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops, as range, and for homesites and other community developments.

Representative profile of Elfrida silty clay loam, 700 feet west and 600 feet south of the northeast corner of sec. 11, T. 16 S., R. 25 E.:

Ap—0 to 13 inches, grayish-brown (10YR 5/2) silty clay loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; few fine and coarse roots; few fine interstitial and tubular pores; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

A12—13 to 22 inches, brown (10YR 5/3) silty clay loam, dark brown (7.5YR 3/2) when moist; weak, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; few fine and coarse roots; few very fine and fine tubular pores; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

C1ca—22 to 33 inches, pinkish-gray (7.5YR 7/2) heavy loam, brown (7.5YR 5/4) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine and medium roots; common very fine and fine tubular pores; violently effervescent; common, fine, pinkish-white (7.5YR 8/2), soft masses and hard nodules of lime; moderately alkaline; abrupt, wavy boundary.

C2ca—33 to 60 inches, pinkish-white (7.5YR 8/2) and pink (7.5YR 7/4) clay loam, pink (7.5YR 7/4) and light brown (7.5YR 6/4) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine roots; common very fine and fine tubular pores; violently effervescent; many, fine and medium, pinkish-white (7.5YR 8/2), soft masses of lime and common fine nodules of lime; moderately alkaline.

The A horizon ranges from dark grayish brown to brown. It is loam, silty clay loam, silt loam, or clay loam and is mildly alkaline to strongly alkaline. Effervescence is slight to strong. Depth to the Cca horizon ranges from 16 to 38 inches, but it is dominantly 20 to 30 inches. The Cca horizon is loam, clay loam, or silty clay loam. Effervescence is strong to violent, and reaction ranges from mildly alkaline to strongly alkaline. Buried clay horizons are below a depth of 4 feet in places.

Elfrida silty clay loam (Ef).—This soil is on flood plains and on lower valley plains and lake margins. Slopes are 0.1 to 0.5 percent. Areas are irregular in shape. They range from 10 to 600 acres but are generally about 70 acres.

Included with this soil in mapping are scattered patches of Elfrida loam, Karro loam, and Pima loam; small areas of Grabe loam, near the town of Cochise; and small spots of Gothard loam, in areas near the lakebed. Also included are small areas where the soil is slightly saline and areas that have 4 to 10 inches of light-colored overburden. Places where piping is active or is beginning are included, and these areas are shown on the soil map by the symbol for a gully.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops, as range, and for homesites and other community developments. Capability units I–1, irrigated, VIc–1, dryland; Loam Upland range site.

Forrest Series

The Forrest series consists of deep, well-drained soils on valley plains and alluvial fans. These soils formed in old alluvium derived from mixed metamorphic, sedimentary, and igneous rocks. Slopes range from 0 to 5 percent. Elevation is 4,200 to 4,600 feet. The vegetation is blue, Rothrock, and hairy grama; tobosa; threeawn; some mesquite; and scattered yucca.

In a representative profile the surface layer is brown loam about 4 inches thick. The subsoil is reddish-brown and red clay about 25 inches thick. The substratum is light-brown and reddish-yellow clay loam and loam that extends to a depth of 60 inches or more. The profile is slightly acid to neutral in the upper part and moderately alkaline in the lower part.

Permeability is slow. Available water capacity is high. Effective rooting depth is 60 inches or more.

These soils are used for irrigated crops, as range, and for homesites and other community developments.

Representative profile of Forrest loam, 0 to 2 percent slopes, 1,200 feet north and 1,200 feet west of the southeast corner of sec. 13, T. 17 S., R. 24 E.; approximately 1 mile north of Sunsites:

A11—0 to 2 inches, brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) when moist; weak, thin, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine and fine roots; many very fine and fine vesicular pores; few fine pebbles; slightly acid; smooth boundary.

A12—2 to 4 inches, brown (7.5YR 5/4) heavy loam, dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots; few fine tubular pores; few fine pebbles; slightly acid; clear, smooth boundary.

B1t—4 to 11 inches, reddish-brown (5YR 4/3) heavy clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium and coarse, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots; few very fine tubular pores; common small pressure faces; neutral; gradual, smooth boundary.

B21t—11 to 16 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; moderate, medium and coarse, subangular and angular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots; few very fine tubular pores; common small pressure faces; mildly alkaline; clear, smooth boundary.

B22t—16 to 20 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; moderate, medium, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots; few very fine tubular pores; common small pressure faces; few fine pebbles; mildly alkaline; clear, wavy boundary.

B23t—20 to 29 inches, red (2.5YR 4/6) clay, dark red (2.5 YR 3/6) when moist; strong, medium, prismatic structure; very hard when dry, firm when moist, sticky and plastic when wet; common very fine and fine roots; many large pressure faces; few fine pebbles; strongly effervescent; moderately alkaline; abrupt, wavy boundary.

C1ca—29 to 35 inches, reddish-yellow (5YR 6/6) clay loam, yellowish red (5YR 5/6) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots; common fine tubular pores; violently effervescent; many, medium and large, pinkish-white (7.5YR 8/2), soft masses of lime; moderately alkaline; gradual, wavy boundary.

C2ca—35 to 50 inches, light-brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; few very fine and fine roots; few fine tubular pores; violently effervescent; many, medium and large, pinkish-white (7.5YR 8/2), soft masses of lime; moderately alkaline; gradual, wavy boundary.

C3ca—50 to 60 inches, light-brown (7.5YR 6/4) loam, strong brown (7.5YR 5/6) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine and fine roots; few fine tubular pores; few pebbles; violently effervescent; common, medium and large, pinkish-white (7.5YR 8/2), soft masses of lime; moderately alkaline.

The solum is 0 to 20 percent gravel, by volume. In places gravel is scattered throughout the profile or is concentrated in thin strata. The A horizon ranges from brown to yellowish red. It is sandy loam, sandy clay loam, gravelly sandy clay loam, or clay loam. The B2t horizon is heavy clay loam, clay, or gravelly clay. The Cca horizon ranges from light brown to pink. It is clay loam, gravelly clay loam, sandy clay loam, gravelly sandy clay loam, loam, sandy loam, or gravelly sandy loam. In places the Cca horizon is weakly cemented. Depth to the Cca horizon ranges from 20 to 40 inches, but it is dominantly 24 to 30 inches.

Forrest loam, 0 to 2 percent slopes (FoA).—This soil is on valley plains and alluvial fans. Slopes are dominantly less than 1 percent. Areas are long and somewhat narrow. They range from 5 to 150 acres in size but are generally about 60 to 70 acres. This soil has the profile described as representative of the series.

Included with this soil in mapping are long, narrow areas of Tubac sandy loam, 0 to 2 percent slopes; areas of Guest clay loam and Pima loam on lower positions; and areas of Sonoita sandy loam on small, rounded ridges. The included soils make up 15 percent of the mapped areas. Also included in places are shallow gullies. Gullied areas are shown on the soil map by a symbol for a gully.

Runoff is slow. The hazard of erosion is slight.

This soil is used for irrigated crops, as range, and for homesites and other community developments. Capability units IIIs–8, irrigated, VIs–1, dryland; Loamy Upland range site.

Forrest gravelly sandy clay loam, 0 to 2 percent slopes (FrA).—This soil is on alluvial fans. Slopes are dominantly 1 to 2 percent. Areas are oval and are about 30 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is gravelly sandy clay loam.

Included with this soil in mapping are areas of Tubac sandy loam, Grabe loam, and Comoro sandy loam. Also included are pockets of Bernardino gravelly sandy clay loam. The included soils make up 10 percent of the mapped areas.

Runoff is slow. The hazard of erosion is slight.

This soil is used for irrigated crops and as range. Capability units IIIs–8, irrigated, VIs–1, dryland; Loamy Upland range site.

Forrest gravelly sandy clay loam, 2 to 5 percent slopes (FrB).—This soil is on alluvial fans. Slopes are dominantly about 3 to 5 percent. Areas are oval and are about 50 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is gravelly sandy clay loam.

Included with this soil in mapping are small areas of Forrest gravelly sandy clay loam, 0 to 2 percent slopes; areas of Bernardino gravelly sandy clay loam and Tubac sandy loam; and areas of Sonoita sandy loam on oval or rounded ridgecrests. The included soils make up about 10 percent of the mapped areas.

Runoff is medium. The hazard of erosion is slight to moderate.

This soil is used for irrigated crops and as range. Capability units IIIe–8, irrigated, VIe–1, dryland; Loamy Upland range site.

Frye Series

The Frye series consists of moderately deep, well-drained soils that have a hardpan. These soils are on valley plains. They formed in alluvium derived from granite, quartzite, andesite, rhyolite, and limestone. Slopes are 0 to 2 percent. Elevation is 4,150 to 4,500 feet. The vegetation is blue, black, and Rothrock grama; tobosa; yucca; and scattered mesquite.

In a representative profile the surface layer is brown sandy loam about 9 inches thick. The upper part of the surface layer is slightly acid, and the lower part is moderately alkaline. The subsoil is brown, reddish-brown, and reddish-yellow clay about 17 inches thick. Below this is a pale-brown and pinkish-gray, silica- and lime-cemented hardpan about 12 inches thick. The underlying material is pale-brown and very pale brown loam and sandy loam to a depth of 93 inches or more.

Permeability is slow above the hardpan. Available

water capacity is low. The effective rooting depth is 18 to 30 inches.

These soils are used for irrigated crops, as range, and for homesites.

Representative profile of Frye sandy loam, 670 feet north and 125 feet west of the southeast corner of sec. 11, T. 12 S., R. 23 E.; about 7 miles west and 9 miles north of Willcox: (See laboratory data.)

A11—0 to 2 inches, brown (7.5YR 5/4) light sandy loam, dark brown (7.5YR 4/4) when moist; moderate, medium, platy structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many fine and very fine roots; many fine interstitial pores; slightly acid; abrupt, smooth boundary.

A12—2 to 6 inches, brown (7.5YR 5/4) sandy loam, dark reddish brown (5YR 3/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many very fine, fine, and medium roots; many fine interstitial pores; moderately alkaline; clear, smooth boundary.

A3—6 to 9 inches, brown (7.5YR 5/4) sandy loam, dark reddish brown (5YR 3/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common fine and very fine roots; many fine interstitial pores and common fine tubular pores; moderately alkaline; abrupt, smooth boundary.

B1—9 to 12 inches, brown (7.5YR 5/4) loam, dark reddish brown (5YR 3/4) when moist; weak, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common fine and very fine roots; common fine and very fine tubular and interstitial pores; few, thin, patchy clay films; moderately alkaline; clear, smooth boundary.

B21t—12 to 23 inches, reddish-brown (5YR 4/4) clay, reddish brown (5YR 4/4) when moist; moderate, medium and coarse, prismatic structure parting to moderate, medium and coarse, angular blocky; hard when dry, firm when moist, sticky and plastic when wet; many fine and very fine exped roots; few fine tubular pores and common exped pores; many thin clay films on faces of peds; moderately alkaline; clear, smooth boundary.

B22tca—23 to 26 inches, reddish-yellow (7.5YR 6/6) clay, yellowish red (5YR 4/6) when moist; moderate, fine and medium, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common fine roots, many in lower part; common fine and very fine tubular and interstitial pores; few thin clay bridges; common, fine, pinkish-white (7.5YR 8/2), soft masses of lime; slightly effervescent; moderately alkaline; abrupt, smooth boundary.

C1sicam—26 to 33 inches, pinkish-gray (7.5YR 6/2), silica- and lime-cemented hardpan, light brown (7.5YR 6/4) when moist; reddish-yellow (7.5YR 6/8) and pink (7.5YR 7/4) mottles on surface of the pan, reddish brown (5YR 5/3) and yellowish red (5YR 5/6) when moist; massive; extremely hard when dry, extremely firm when moist; few roots in occasional fractures; silica laminae on surface of hardpan; strongly effervescent; moderately alkaline; clear, smooth boundary.

C2sicam—33 to 38 inches, pale-brown (10YR 6/3), silica- and lime-cemented hardpan, dark brown (10YR 4/3) when moist; massive; extremely hard when dry, extremely firm when moist; few fine tubular pores; few krotovinas; many, fine and medium, white (N 8/0), hard masses of lime; violently effervescent; moderately alkaline; clear, wavy boundary.

C3sica—38 to 56 inches, very pale brown (10YR 7/3) and pale-brown (10YR 6/3) loam, brown to dark brown (7.5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; many fine and very fine and few medium tubular pores; few hard durinodes; violently effervescent; moderately alkaline; clear, smooth boundary.

C4ca—56 to 80 inches, mottled, pale-brown (10YR 6/3), brown (7.5YR 5/4), and very pale brown (10YR 8/4) loam, brown (7.5YR 5/4) and dark brown 8/4) loam, brown (7.5YR 5/4) and dark brown when dry, very friable when moist, nonsticky and slightly plastic when wet; many fine and very fine and few medium tubular pores; strongly effervescent; moderately alkaline; clear, smooth boundary.

C5—80 to 93 inches, pale-brown (10YR 6/3) and brown (7.5YR 5/4) sandy loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist, nonsticky and slightly plastic when wet; many fine and very fine and few medium tubular pores; noneffervescent; moderately alkaline.

The A horizon ranges from brown to yellowish red. It is sandy loam, sandy clay loam, clay loam, and loam and is slightly acid to moderately alkaline. The B2t horizon is heavy clay loam and clay. It is moderately alkaline to strongly alkaline. Depth to the Csicam horizon (duripan) ranges from 18 to 30 inches but is generally about 22 to 26 inches. The duripan is 6 to 24 inches thick. The soil material below the duripan is variable in texture and thickness. It ranges from clay loam to sandy loam.

Frye sandy loam (Fy).—This soil is in the Stewart District, just north of Willcox. Slopes are dominantly 0.2 to 1.5 percent. Areas range from 20 to 190 acres but are generally about 40 acres. They are long and narrow.

Included with this soil in mapping, especially in cultivated fields, are areas where the surface layer is sandy clay loam; long, narrow areas of Tubac sandy loam, 0 to 2 percent slopes; long, narrow areas of Sonoita sandy loam, 0 to 2 percent slopes, on ridgetops; areas of McAllister loam on lower positions; and areas of Pima loam in swales and drainageways. Also included along drainageways are areas of Frye soils that have slopes of 2 to 5 percent. The included soils make up about 25 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops, as range, and for homesites. Capability units IIIs–5, irrigated, VIs–1, dryland; Loamy Upland range site.

Gothard Series

The Gothard series consists of deep, moderately well drained, alkali-affected soils on alkali flats that border playas. These soils formed in lacustrine sediment and alluvium derived from mixed rock sources that include acid and basic igneous, sedimentary, and metamorphic rocks. Slopes are 0 to 0.5 percent, but in places the surface has uneven microrelief because of soil blowing. Elevation is 4,137 to 4,200 feet. The vegetation is alkali sacaton, inland saltgrass, tobosa, saltbush, scattered mesquite, and annual weeds and grasses. As much as 50 percent of the surface is barren.

In a representative profile the surface layer is light brownish-gray and light-gray fine sandy loam about 5 inches thick. The subsoil is grayish-brown, pale-brown, and pink light clay loam and heavy loam about 37 inches thick. The substratum is light-gray to olive-brown stratified sandy loam and loamy sand that has thin lenses of sandy clay loam to a depth of 80 inches or more. The profile is strongly alkaline to very strongly alkaline.

Permeability is very slow. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used as range and for homesites and other community developments.

Representative profile of Gothard fine sandy loam, 1/2 mile west and 100 feet north of the east quarter corner of sec. 27, T. 16 S., R. 25 E.; 16 1/2 miles south and 2 3/4 miles east of Willcox: (See laboratory data.)

A1—0 to 2 inches, light brownish-gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium and thin, platy structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common fine and medium roots; common fine and few medium tubular pores; slightly effervescent; strongly alkaline; abrupt, smooth boundary.

A2—2 to 5 inches, light-gray (10YR 6/1) fine sandy loam, dark grayish brown (10YR 4/2) when moist; massive; hard when dry, friable when moist, nonsticky and nonplastic when wet; common fine and medium roots; many very fine and few fine tubular pores; strongly effervescent; strongly alkaline; abrupt, smooth boundary.

B21t—5 to 11 inches, grayish-brown (10YR 5/2) light clay loam, dark grayish brown (10YR 4/2) when moist; moderate, fine and medium, prismatic structure parting to moderate, fine and medium, angular and subangular blocky; hard when dry, firm when moist, sticky and plastic when wet; common fine and medium roots; many very fine interstitial pores and common fine and very fine tubular pores; common thin clay films on faces of peds and in pores; slightly effervescent; strongly alkaline; clear, smooth boundary.

B22tca—11 to 24 inches, pale-brown (10YR 6/3) heavy loam, brown (10YR 4/3) when moist; strong, fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many fine and medium roots in upper 6 inches, common fine and medium roots in lower 7 inches; many fine and common medium tubular pores; few thin clay films on faces of peds; many, fine, light-gray (10YR 7/2), soft masses of lime; strongly effervescent; very strongly alkaline; abrupt, wavy boundary.

B23tca—24 to 42 inches, pink (7.5YR 7/4) light clay loam, brown (7.5YR 5/4) when moist; common, medium, faint, reddish-yellow (7.5YR 6/6) coatings on peds; weak, coarse, prismatic structure parting to moderate, medium, angular and subangular blocky; very hard when dry, firm when moist, sticky and plastic when wet; common fine exped roots; many fine and common very fine tubular pores; thin, continuous clay films on faces of peds and lining pores; slightly effervescent; many, medium and large, white (N 8/0), soft masses of lime; very strongly alkaline; abrupt, wavy boundary.

C1ca—42 to 51 inches, light-gray (2.5Y 7/2) sandy loam, grayish-brown (2.5Y 5/2) when moist; few, fine, distinct, black (N 2/0) mottles; massive; extremely hard when dry, firm when moist, sticky and plastic when wet; common fine and very fine tubular pores; slightly effervescent; common, fine and medium, white (N 8/0) masses of lime; strongly alkaline; abrupt, wavy boundary.

C2ca—51 to 80 inches, light-gray (2.5Y 7/2), stratified loamy sand to light sandy loam that has thin lenses of sandy clay loam; grayish brown (2.5Y 5/2) when moist; few, fine and medium, distinct, light olive-brown (2.5Y 5/6) coatings; massive; weakly cemented; very hard when dry, friable when moist, nonsticky and nonplastic when wet; common fine and few medium tubular pores; slightly effervescent in spots; strongly alkaline.

The A1 horizon ranges from grayish brown to very pale brown. It is normally sandy loam, fine sandy loam, loam, or silt loam, but it is clay loam in some plowed areas. It is moderately alkaline to very strongly alkaline. The content of exchangeable sodium is more than 35 percent. Depth to the Cca horizon ranges from 20 inches to more than 40 inches. The C horizon is highly stratified and ranges from clay to loamy sand; each stratum varies in thickness. Reaction is strongly alkaline to very strongly alkaline.

Gothard fine sandy loam (Go).—This soil is in the vicinity of Willcox and on the southeast side of the Willcox Playa. Slopes are dominantly 0.1 to 0.5 percent. Areas are irregular in shape and are about 50 to 60 acres in size.

Included with this soil in mapping are small areas of Gothard sandy loam that has slopes of 2 to 5 percent, shown on the soil map by escarpment symbols; scattered areas of Crot sandy loam, Stewart loam, and Karro loam; areas of Comoro sandy loam and Comoro sandy loam, alkali variant, on long, narrow and oval, slightly elevated ridges; and scattered areas of Duncan loam in the vicinity of Willcox. Also included are small, round saline spots. The included soils make up about 20 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used as range and for homesites and other community developments. It is a possible source of sand and gravel. Capability unit VIIs-1, dryland; Saline Bottom range site.

Grabe Series

The Grabe series consists of deep, well-drained soils on flood plains and low terraces. These soils formed in mixed alluvium derived from acid and basic, igneous and sedimentary rocks. Slopes are 0 to 2 percent. Elevation is 4,200 to 4,600 feet. The vegetation is tobosa, giant sacaton, black grama, sand beardgrass, spike dropseed, Arizona cottontop, three-awn, burroweed, yucca, and scattered mesquite.

In a representative profile the surface layer is stratified, brown, dark-brown, and dark grayish-brown loam and sandy loam 40 inches thick. The underlying material is pale-brown sandy loam to a depth of 60 inches or more. Below a depth of 2 inches, the soil is moderately alkaline.

Permeability is moderate. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops, as range, and for homesites and other community developments.

Representative profile of Grabe loam, 2,400 feet south and 800 feet west of the northeast corner of sec. 4, T. 17 S., R. 24 E.:

A11—0 to 2 inches, brown (10YR 5/3) loam, very dark grayish brown (10YR 3/2) when moist; weak, thin, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine roots; common very fine vesicular pores; 5 percent gravel; slightly effervescent; neutral; abrupt, smooth boundary.

A12—2 to 10 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common very fine and fine roots and few medium roots; many fine and medium tubular pores; slightly effervescent; moderately alkaline; clear, wavy boundary.

A13—10 to 21 inches, dark-brown (10YR 4/3) loam, very dark grayish brown (10YR 3/2) when moist; weak, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common very fine and fine and few medium roots; many very fine and fine tubular pores; 5 percent gravel; few, fine,

white (10YR 8/2) filaments of lime; slightly effervescent; moderately alkaline; clear, wavy boundary.

A14—21 to 30 inches, brown (10YR 5/3) loam, very dark grayish brown (10YR 3/2) when moist; weak, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; common very fine and few fine roots; many very fine and fine tubular pores; 5 percent gravel; common, fine, white (10YR 8/2) filaments of lime; strongly effervescent; moderately alkaline; clear, wavy boundary.

A15—30 to 40 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine roots; many very fine tubular pores; 5 percent gravel; few, fine, white (10YR 8/2) filaments of lime; strongly effervescent; moderately alkaline; clear, wavy boundary.

C1—40 to 60 inches, pale-brown (10YR 6/3) sandy loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and slightly plastic when wet; few very fine, fine, and medium roots; many very fine and fine tubular pores; 5 percent fine gravel; strongly effervescent; moderately alkaline.

The A horizon is sandy loam, fine sandy loam, loam, or silt loam. In places it has some gravel. The C horizon is mildly alkaline to moderately alkaline and slightly effervescent. It is mainly sandy loam, fine sandy loam, silt loam, and loam but includes strata of loamy sand that are less than 3 inches thick.

Grabe sandy loam (Gr).—This soil is in long, somewhat narrow and irregularly shaped areas of about 60 acres. The profile of this soil is similar to the one described as representative of the series, but the surface layer is sandy loam (fig. 2).

Included with this soil in mapping are small areas of Comoro sandy loam on slightly elevated ridges; areas of Pima loam and Guest loam in depressions and drainageways; and areas, near Tubac and Forrest soils, of a soil that is similar to Grabe soils but is underlain by reddish clay loam or clay at a depth of about 30 to 40 inches. Also included are long, narrow, sharp breaks along drainageways, shown on the soil map by escarpment symbols. The included soils make up about 15 percent of the mapped areas.

Runoff is slow to medium. The hazard of water erosion is slight. The hazard of soil blowing is slight to moderate.

Grabe sandy loam is used for irrigated crops, as range, and for homesites and other community developments. Capability units I–1, irrigated, VIc–1, dryland; Loam Bottom range site.

Grabe loam (Gs).—This soil occurs throughout the survey area. Some areas are long and somewhat narrow, and some are irregularly shaped. Most areas are about 100 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of Comoro sandy loam on slightly elevated ridges; areas of Pima loam and Guest loam in swales and drainageways; and areas, near Tubac and Forrest soils, of a soil that is similar to Grabe soils but is underlain by reddish clay loam or clay at a depth of about 30 inches. Also included are long, very narrow, sharp breaks along drainageways that are shown on the soil map by escarpment symbols and small areas of soils that have a gravelly surface layer that are shown by gravel symbols. The included soils make up about 15 percent of the mapped areas.

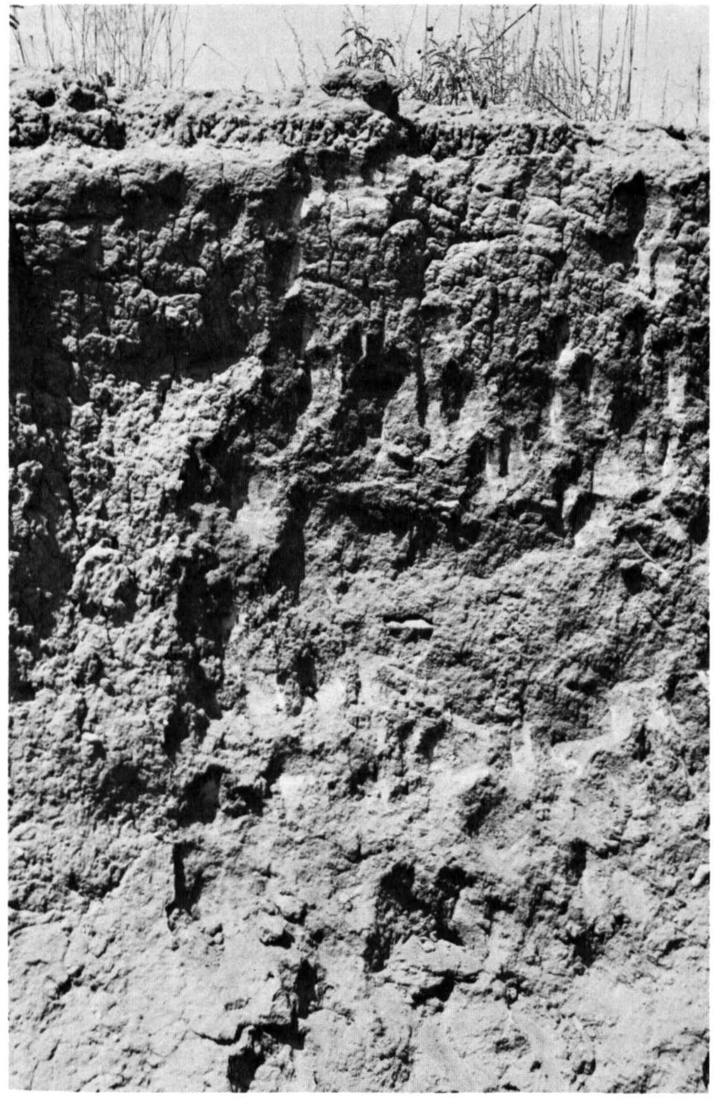

Figure 2.—**Profile of Grabe sandy loam, shows deep, dark-colored, moderately permeable soil.**

Runoff is slow, and the hazard of erosion is slight.

Grabe loam is used for irrigated crops, as range, and for homesites and other community developments. Capability units I–1, irrigated, VIc–1, dryland; Loam Bottom range site.

Guest Series

The Guest series consists of deep, well-drained soils on flood plains and low terraces. These soils formed in mixed alluvium derived from acid and basic, igneous and sedimentary rocks. Slopes range from 0 to 2 percent. Elevation is 4,200 to 4,500 feet. The vegetation is tobosa, vine-mesquite, black and blue grama, and scattered mesquite.

In a representative profile the surface layer is brown clay loam and clay to a depth of 60 inches or more. The profile is moderately alkaline throughout.

Permeability is slow. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops, as range, and for homesites and other community developments.

Representative profile of Guest clay loam, 660 feet west of northeast corner of sec. 20, T. 11 S., R. 23 E.:

Ap—0 to 8 inches, brown (10YR 5/3) clay loam, very dark grayish brown (10YR 3/2) when moist; weak, fine and medium, granular structure; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; common fine and very fine roots; few medium and coarse and common fine and very fine tubular pores; slightly effervescent; moderately alkaline; clear, wavy boundary.

A12—8 to 18 inches, brown (10YR 5/3) clay loam, dark brown (10YR 3/3) when moist; weak, fine, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common fine and very fine roots; few medium and common fine and very fine tubular pores; slightly effervescent; moderately alkaline; clear, smooth boundary.

A13—18 to 35 inches, brown (10YR 4/3) clay, dark brown (7.5YR 3/2) when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; few very fine roots; many fine and very fine tubular pores; slightly effervescent; moderately alkaline; clear, wavy boundary.

A14—35 to 60 inches, brown to dark-brown (10YR 4/3) clay, dark brown (7.5YR 3/2) when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; few very fine roots; many fine and very fine tubular pores; slightly effervescent; moderately alkaline.

The A horizon ranges from dark grayish brown to brown. The upper part is either clay loam or clay, and the lower part is light clay or clay. Reaction ranges from mildly alkaline to moderately alkaline, and the soil is slightly to strongly effervescent. Some profiles have few to common small slickensides below a depth of 30 inches; some have buried horizons of reddish-brown to yellowish-red clay that has common, medium and large, white, soft masses of lime.

Guest clay loam (Gt).—This soil has slopes that are dominantly 0.1 to 0.5 percent. Areas are narrow and elongated. They range from about 40 to 50 acres. This soil has the profile described as representative of the series.

Included with this soil in mapping are small, long and narrow areas of Guest clay, Pima loam, and Cogswell clay loam in swales and areas of Tubac sandy clay loam and Forrest sandy loam. Also included near Tubac and Forrest soils are areas of Guest soils that have buried horizons of reddish clay or clay loam between depths of 30 and 40 inches. The included soils make up about 15 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops, as range, and for homesites and other community developments. Capability units IIIs–8, irrigated, VIs–1, dryland; Clay Bottom range site.

Guest clay (Gu).—This soil has slopes that are dominantly 0.1 to 0.5 percent. Areas are narrow and elongated in shape and about 60 to 70 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is clay.

Included with this soil in mapping are areas of Guest clay loam; long, narrow areas of Cogswell clay loam and Pima loam in swales; areas of Tubac and Forrest sandy loams; and small areas, near Forrest and Tubac soils, where reddish clay or clay loam underlies this Guest soil at a depth of 30 to 40 inches. Also included are small spots of Guest clay, which is strongly alkaline. The included soils make up 15 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops and as range. Capability units IIIs–3, irrigated, VIs–1, dryland; Clay Bottom range site.

Karro Series

The Karro series consists of deep, well-drained soils on valley plains and lake margins. These soils formed in mixed alluvium derived from acid and basic igneous rocks and limestone. Slopes are less than 1 percent. Elevation is 4,140 to 4,300 feet. The vegetation is alkali sacaton, fluffgrass, tobosa, creosotebush, saltbush, blackbrush, and mesquite.

In a representative profile the surface layer is light brownish-gray and pale-brown loam about 11 inches thick. The underlying material is pale-brown, light-gray, and white loam and clay loam to a depth of 60 inches or more. The profile is high in calcium carbonate and is moderately alkaline throughout.

Permeability is moderately slow. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops and for homesites and other community developments.

Representative profile of Karro loam, 150 feet west and 900 feet north of the southeast corner of sec. 23, T. 15 S., R. 25 E.:

Ap1—0 to 2 inches, light brownish-gray (10YR 6/2) loam, dark brown (10YR 3/3) when moist; weak, medium and thick, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and coarse roots; few very fine tubular pores; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

Ap2—2 to 11 inches, pale-brown (10YR 6/3) loam, dark brown (10YR 3/3) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots and common coarse roots; many fine interstitial pores and few very fine tubular pores; strongly effervescent; moderately alkaline; clear, wavy boundary.

C1—11 to 15 inches, pale-brown (10YR 6/3) loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots; common fine and very fine tubular pores; few, fine, hard nodules of lime; violently effervescent; moderately alkaline; clear, smooth boundary.

C2ca—15 to 30 inches, light-gray (10YR 7/2) clay loam, pale brown (10YR 6/3) when moist; common light brownish-gray (10YR 6/2) coatings, brown (10YR 5/3) when moist; moderate, fine and medium, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; common fine and medium roots; many fine tubular pores; many, fine and medium, white (N 8/0), very hard nodules and soft masses of lime; violently effervescent; very strongly alkaline; gradual, wavy boundary.

C3ca—30 to 45 inches, white (10YR 8/1) clay loam, white (10YR 8/2) when moist; few light-gray (10YR 7/2) coatings, light brownish gray (10YR 6/2) when moist; moderate, medium and fine, angular and subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few fine roots; many very fine tubular and interstitial pores; many, medium and coarse, irregularly

shaped, very hard nodules of lime; violently effervescent; very strongly alkaline; gradual, wavy boundary.

C4ca—45 to 60 inches, white (10YR 8/2) and light yellowish-brown (10YR 6/4) clay loam, light gray (10YR 7/2) and yellowish brown (10YR 5/4) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; many, fine, medium, and coarse, irregularly shaped, very hard nodules of lime; violently effervescent; strongly alkaline.

The Ap horizon ranges from grayish brown to very pale brown. It is sandy loam, loam, or silt loam. Depth to the Cca horizon ranges from 10 to 24 inches but averages about 16 inches. The Cca horizon is loam, silt loam, or clay loam. It is more than 40 percent calcium carbonate. In places it is weakly cemented with lime.

Karro loam (Ka).—This soil has slopes that are dominantly less than 0.5 percent. Areas are oval or irregular in shape and are about 75 to 80 acres in size.

Included with this soil in mapping are small, scattered areas of Elfrida loam and Pima loam in drainageways and in swales, respectively, and areas of Gothard loam near the lake margin. Also included are isolated saline-alkali spots, areas of soils that are similar to Karro soils but have clay strata overlying the marly materials, and a long, narrow ridge of Karro loam, just south of Cochise, where slopes are 5 to 9 percent. This ridge is shown on the soil map by an escarpment symbol. The included soils make up about 10 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops, as range, and for homesites and other community developments. Capability units IIs–7, irrigated, VIs–1, dryland; Limy Upland range site.

Kimbrough Series

The Kimbrough series consists of shallow and very shallow, well-drained soils that have a hardpan. These soils are on valley plains and foothills. The soils formed in mixed alluvium derived from acid and basic igneous rocks and limestone. Slopes range from 0 to 25 percent. Elevation is 4,200 to 4,800 feet. The vegetation is black, blue, and side-oats grama; Mormon tea; yucca; croton; and scattered mesquite.

In a representative profile the surface layer is dark grayish-brown gravelly loam about 10 inches thick. Below this is a lime-cemented hardpan that extends to a depth of 16 inches or more. The profile is moderately alkaline throughout.

Permeability is moderate above the hardpan. Available water capacity is very low. The effective rooting depth is 4 to 20 inches.

These soils are used as range and for homesites and other community developments.

Representative profile of Kimbrough gravelly loam, 2 to 25 percent slopes, 1,350 feet north and 600 feet east of the southwest corner of sec. 16, T. 17 S., R. 26 E.:

A11—0 to 3 inches, dark grayish-brown (10YR 4/2) gravelly loam, dark brown (7.5YR 3/2) when moist; weak, thin, platy structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots; many fine interstitial pores; 10 percent gravel in profile, 60 percent gravel on surface; slightly effervescent; mildly alkaline; clear, smooth boundary.

A12—3 to 10 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish-brown (10YR 3/2) when moist; weak, medium, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots; many fine interstitial pores; 10 percent fine gravel; violently effervescent; moderately alkaline; abrupt, wavy boundary.

Ccam—10 to 16 inches, white (10YR 8/2), lime-cemented hardpan, very pale brown (10YR 8/4) when moist; extremely hard when dry, extremely firm when moist; violently effervescent.

The A horizon ranges from dark grayish brown to brown. It is gravelly loam or loam. The content of coarse fragments is 5 to 35 percent. Forty to 80 percent of the surface, in places, is covered with gravel. Depth to the Ccam (hardpan) horizon ranges from 4 to 20 inches.

Kimbrough gravelly loam, 2 to 25 percent slopes (KbE).—This soil is on the lower part of hills that crop out of the valley floor in the southern and southeastern parts of the survey area. Areas are either long and narrow or oval in shape and are about 150 to 200 acres in size.

Included with this soil in mapping are small areas of Cave gravelly loam on the lower part of slopes and on south-facing slopes; areas of Kimbrough very cobbly loam, shallow over bedrock variant, on the upper part of slopes; about 200 acres near Cochise Stronghold of a soil similar to Kimbrough soils that is very gravelly and very shallow over limestone; and small outcrops of limestone. Also included are small pockets of a soil that is moderately deep over a lime-cemented hardpan. The included soils make up about 15 percent of the mapped areas.

Runoff is medium, and the hazard of erosion is moderate.

This soil is used as range and for homesites. Capability unit VIs–1, dryland; Limy Upland range site.

Kimbrough Variant

The Kimbrough variant consists of shallow and very shallow, well-drained soils over bedrock that has a thin, hardpan cap. These soils are on foothills. They formed in alluvium derived from limestone and deposited over fine-grained igneous bedrock. Slopes range from 15 to 30 percent. Elevation is 4,300 to 4,900 feet. The vegetation is side-oats grama, tanglehead, black grama, three-awn, cane beardgrass, yucca, guajillo, Mormon tea, and some scattered small mesquite.

In a representative profile the surface layer is brown very cobbly loam and gravelly loam about 5 inches thick. Below this is a white, lime-cemented hardpan about 3 inches thick. Below the hardpan is gray rhyolite that extends to a depth of 12 inches or more. The profile is moderately alkaline.

Permeability is moderate above the hardpan. Available water capacity is very low. The effective rooting depth is 4 to 20 inches.

These soils are used as range.

Representative profile of Kimbrough very cobbly loam, shallow over bedrock variant, 15 to 30 percent slopes, 1,600 feet south and 1,150 feet east of the northwest corner of sec. 9, T. 17 S., R. 26 E.:

A11—0 to 2 inches, brown (10YR 5/3) very cobbly and gravelly loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist, slightly

sticky and slightly plastic when wet; many fine and medium roots; few fine tubular pores; 55 percent gravel and cobbles; slightly effervescent; moderately alkaline; clear, smooth boundary.

A12—2 to 5 inches, brown (10YR 5/3) gravelly loam, very dark brown (10YR 2/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots; few fine tubular pores; 40 percent gravel and cobbles; slightly effervescent; moderately alkaline; abrupt, wavy boundary.

Ccam—5 to 8 inches, white (N 8/0) lime-cemented hardpan, pinkish white (7.5YR 8/2) when moist; massive; extremely hard when dry, extremely firm when moist; violently effervescent; abrupt, wavy boundary.

R—8 to 12 inches, gray (10YR 5/1) rhyolite.

The A horizon ranges from dark grayish brown to brown. It is very cobbly loam or very cobbly clay loam. It is mildly alkaline or moderately alkaline and slightly effervescent to strongly effervescent. Fifty to 80 percent of the surface is covered with cobbles and gravel. The profile is 35 to 50 percent cobbles and gravel. Depth to the Ccam horizon is 4 to 20 inches. The Ccam horizon is a lime-cemented hardpan, ½ inch to 4 inches thick, over rhyolite or andesite.

Kimbrough very cobbly loam, shallow over bedrock variant, 15 to 30 percent slopes (KhE).—This soil is on the higher parts of hills in the southern and southeastern parts of the survey area. Areas are rounded and oval in shape and are about 40 to 50 acres in size.

Included with this soil in mapping are small areas of Kimbrough gravelly loam, 2 to 25 percent slopes, on the lower part of slopes; small, rounded areas of a very cobbly, fine-textured soil on the highest part of the hills; and areas of rhyolite and andesite rock outcrops. The included soils make up about 20 percent of the mapped areas.

Runoff is medium, and the hazard of erosion is moderate.

This soil is used as range. Capability unit VIIs-1, dryland; Limy Upland range site.

Luzena Series

The Luzena series consists of shallow and very shallow, well-drained soils over bedrock. These soils are on hills. They formed in residuum that weathered from gneiss, andesite, dacite, rhyolite, or associated tuff or agglomerate. Slopes range from 5 to 15 percent. Elevation is 4,300 to 4,800 feet. The vegetation is side-oats grama, blue grama, tobosa, fluffgrass, and scattered yucca and mesquite.

In a representative profile the surface layer is dark-brown gravelly clay loam about 4 inches thick. The subsoil is dark reddish-brown and reddish-brown clay about 9 inches thick. Below this is fractured gneiss that extends to a depth of more than 60 inches. The profile is neutral to mildly alkaline.

Permeability is slow above the bedrock. Available water capacity is very low. The effective rooting depth is 7 to 20 inches.

These soils are used as range and for homesites.

Representative profile of Luzena clay loam, 5 to 15 percent slopes, 800 feet east of the northwest corner of sec. 33, T. 17 S., R. 24 E.; 23 miles south and 5 miles west of Willcox:

A1—0 to 4 inches, dark-brown (7.5YR 4/2) gravelly clay loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common very fine roots; 25 percent gravel; neutral; clear, smooth boundary.

B21t—4 to 8 inches, dark reddish-brown (5YR 3/3) clay, dark reddish brown (5YR 3/3) when moist; moderate, very fine and fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common very fine roots; few very fine tubular pores; few thin clay films on faces of peds; 10 percent gravel; neutral; clear, smooth boundary.

B22t—8 to 13 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few very fine roots; few thin clay films on faces of peds; 10 percent gravel; slightly effervescent; mildly alkaline; abrupt, irregular boundary.

R—13 to 60 inches, gray (10YR 5/1), fractured gneiss.

The A horizon ranges from very dark grayish brown to brown. It is gravelly clay loam or gravelly loam and is 15 to 30 percent gravel. It is slightly acid to neutral. The B2t horizon is heavy clay loam, clay, or gravelly clay. It is 5 to 25 percent gravel. It is neutral to mildly alkaline and noneffervescent to slightly effervescent. Depth to fractured bedrock ranges from 10 to 20 inches. Bedrock, in places, is slightly weathered in the upper part.

Luzena gravelly clay loam, 5 to 15 percent slopes (LuD).—This soil is on low hills and foot slopes in the southwestern part of the survey area. Areas are round or oval and are about 40 acres in size.

Included with this soil in mapping are small, narrow bands of Tubac sandy loam and Sonoita sandy loam on foot slopes; areas of Comoro sandy loam in narrow stringers on the lower foot slopes; and areas of Tubac gravelly loam, 10 to 20 percent slopes, on the lower part of some steeper hills. Also included is about 200 acres of rock outcrop and calcareous gravelly loam that is shallow over schist. This area is adjacent to the Yucca Sierra Country Club, north of Willcox. The included soils make up about 15 percent of the mapped areas.

Runoff is medium, and the hazard of erosion is moderate.

This soil is used as range and for homesites. Capability unit VIe-1, dryland; Loamy Upland range site.

Luzena Variant

The Luzena variant consists of shallow, well-drained soils on hills. These soils formed in residuum that weathered from andesite, dacite, rhyolite, and associated tuff or agglomerate. Slopes range from 15 to 30 percent. Elevation is 4,400 to 4,900 feet. The vegetation is tanglehead, side-oats grama, blue grama, cane beardgrass, woolly bunchgrass, sprucetop grama, plains lovegrass, tobosa, and scattered yucca and mesquite.

In a representative profile the surface layer is brown very cobbly loam about 3 inches thick. The subsoil is reddish-brown and dark-red cobbly clay about 15 inches thick. Below this is extremely hard dacite that extends to a depth of 27 inches or more. The profile is medium acid to mildly alkaline.

Permeability is slow above the bedrock. Available water capacity is very low. The effective rooting depth is 10 to 20 inches.

These soils are used as range.

Representative profile of Luzena very cobbly loam, very cobbly subsoil variant, 15 to 30 percent slopes,

100 feet south and 750 feet east of the northwest corner of sec. 3, T. 17 S., R. 25 E.; 24 miles south and 4 miles east of Willcox:

A1—0 to 3 inches, brown (7.5YR 5/4) very cobbly loam, very dark brown (5YR 3/4) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots; few very fine tubular pores; 60 percent cobbles and gravel; mildly alkaline; abrupt, smooth boundary.

B1t—3 to 8 inches, reddish-brown (5YR 4/3) cobbly clay loam, dark reddish brown (5YR 3/4) when moist; weak, medium, angular and subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; many fine and medium roots; few very fine tubular pores; few thin clay films on faces of peds; approximately 40 percent gravel and cobbles; medium acid; clear, wavy boundary.

B21t—8 to 11 inches, reddish-brown (5YR 4/3) cobbly clay, dark reddish brown (5YR 3/4) when moist; moderate, fine, angular blocky structure; slightly hard when dry, friable when moist, sticky and very plastic when wet; few fine and medium roots; few very fine tubular pores; common thin clay films on faces of peds; 40 percent cobbles and gravel; mildly alkaline; gradual, wavy boundary.

B22t—11 to 18 inches, dark-red (2.5YR 3/6) cobbly clay, dark red (2.5YR 3/6) when moist; moderate, fine, angular blocky structure; slightly hard when dry, friable when moist, slightly sticky and very plastic when wet; few fine and medium roots; few very fine tubular pores; common thin clay films on faces of peds; 40 percent cobbles and gravel; mildly alkaline; abrupt, wavy boundary.

R—18 to 27 inches, extremely hard dacite; thin coatings of calcium carbonate on rock surfaces and a thin, discontinuous laminar layer on bedrock surface.

The profile is 50 to 65 percent cobbles and gravel. The A1 horizon ranges from dark grayish brown to brown. It is very cobbly loam or very cobbly clay loam and is slightly acid to mildly alkaline. The B2t horizon is 35 to 55 percent cobbles and gravel. It is medium acid to mildly alkaline. Depth to bedrock ranges from 10 to 20 inches.

Luzena very cobbly loam, very cobbly subsoil variant, 15 to 30 percent slopes (LvE).—This soil is on round and oval- or cone-shaped hills that crop out from the valley floor in the southern part of the survey area. Areas range from about 70 to 75 acres.

Included with this soil in mapping are small, narrow bands of Tubac gravelly loam, 10 to 20 percent slopes, on the lower foot slopes; areas of Kimbrough very cobbly loam, shallow over bedrock variant, on the lower part of slopes; and rhyolite or dacite rock outcrops on the upper part of hills. The included soils make up about 20 percent of the mapped areas.

Runoff is medium, and the hazard of erosion is moderate.

The soil is used as range. Capability unit VIIs–1, dryland; Loamy Hills range site.

McAllister Series

The McAllister series consists of deep, well-drained soils on valley slopes and plains. These soils formed in mixed alluvium derived from igneous, metamorphic, and sedimentary rocks. Slopes are 0 to 2 percent. Elevation is 4,100 to 4,300 feet. The vegetation is alkali sacaton, tobosa, burrograss, fluffgrass, and mesquite.

In a representative profile the surface layer is brown loam about 12 inches thick. The subsoil is brown and light-brown clay loam about 35 inches thick. The substratum is light-brown fine sandy loam and mottled, yellowish-brown, brown, and pinkish-gray loam to a depth of 80 inches or more. The profile is moderately alkaline and strongly alkaline throughout.

Permeability is slow. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops and as range.

Representative profile of McAllister loam, 1,100 feet east and 900 feet south of the west quarter corner of sec. 10, T. 13 S., R. 24 E.:

Ap—0 to 12 inches, brown (10YR 5/3) loam, dark brown (7.5YR 4/2) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and few medium roots; many fine and very fine interstitial pores; few fine pebbles; strongly effervescent; moderately alkaline; clear, wavy boundary.

B21t—12 to 16 inches, brown (7.5YR 5/4) clay loam, reddish brown (5YR 4/4) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; many fine and few medium roots; common fine and very fine tubular pores; common thin clay films in tubular pores; few fine pebbles; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

B22t—16 to 24 inches, brown (7.5YR 5/4) clay loam, reddish brown (5YR 4/4) when moist; moderate, fine, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; common fine roots; common fine interstitial pores; common thin clay films on faces of peds; few fine pebbles; strongly effervescent; many medium worm holes filled with light brownish-gray (10YR 6/2), calcareous soil material; moderately alkaline; clear, smooth boundary.

B23tca—24 to 47 inches, light-brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) when moist; common black (10YR 2/1) manganese coatings on faces of peds; moderate, fine, subangular and angular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; few fine roots; many fine interstitial pores and many fine and very fine tubular pores; many thin clay films on faces of peds; many, fine and medium, pinkish-white (7.5YR 8/2), soft masses of lime and many ¼- to ¾-inch concretions of lime; violently effervescent; moderately alkaline; clear, wavy boundary.

C1ca—47 to 72 inches, light-brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) when moist; common black (10YR 2/1) manganese coatings in old root channels; massive; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; few fine roots; many fine and very fine tubular pores; few, fine, white (10YR 8/1), soft masses of lime and common ¼- to ¾-inch concretions of lime; moderately alkaline; gradual, wavy boundary.

C2ca—72 to 80 inches, mottled, yellowish-brown (10YR 5/6), brown (7.5YR 5/2), and pinkish-gray (7.5YR 6/2) loam, brown (7.5YR 5/2), dark brown (7.5YR 4/2), and dark yellowish brown (10YR 4/4) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; few fine roots; few fine and common medium and coarse tubular pores; common to many, very fine, soft, black (10YR 2/1) manganese shot; strongly effervescent; common ½-inch concretions of lime; strongly alkaline.

The A horizon ranges from grayish brown to very pale brown. It is sandy loam, loam, or clay loam and is moderately alkaline to very strongly alkaline. It is moderately or strongly effervescent. The B2t horizon is clay loam or silty clay loam, and is less than 15 percent gravel. It is moderately alkaline or strongly alkaline. Depth to the Cca horizon ranges from 20 to 36 inches, but it is dominantly

about 24 inches. The Cca horizon is weakly cemented in places.

McAllister loam (Mc).—This soil is mainly in the Stewart District, north of Willcox. Slopes are dominantly less than 0.5 percent. Areas are long and narrow and are about 75 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of McAllister loam, alkali; areas of Gothard loam close to the old lake margins; scattered areas of Frye sandy loam; and areas of Cogswell clay loam. Also included are small, rounded, saline-alkali areas that are locally called "white spots." These spots are shown by spot symbols on the soil map. The included soils make up about 15 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops (fig. 3) and as range. Capability units I-1, irrigated, VIc-1, dryland; Loamy Upland range site.

McAllister loam, alkali (Mk).—This soil is in the Stewart District, north of Willcox. Slopes are dominantly less than 0.5 percent. Areas are long and narrow and are about 50 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is strongly alkaline or very strongly alkaline.

Included with this soil in mapping are small, scattered spots of McAllister loam; areas of Gothard loam and Cogswell clay loam near the old lake margin and in swales; and small, isolated areas of Frye sandy loam on slightly higher positions. The included soils make up about 10 percent of the mapped areas.

Runoff is very slow, and the hazard of erosion is slight.

This soil is used for irrigated crops and as range. Capability units IIIs–9, irrigated, VIIs–1, dryland; Loamy Upland range site.

Pima Series

The Pima series consists of deep, well-drained soils on flood plains and low terraces. These soils formed in alluvium derived from acid and basic, igneous and sedimentary rocks. Slopes are 0 to 2 percent. Elevation is 4,100 to 4,600 feet. The vegetation is vine-mesquite, tobosa, cane beardgrass, black grama, curly mesquite, and mesquite.

In a representative profile the surface layer is brown and grayish-brown loam, clay loam, and silty clay loam about 30 inches thick. The underlying material is light-brown heavy loam to a depth of 60 inches or more. The profile is moderately alkaline.

Permeability is moderately slow. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops, as range, and for homesites and other community developments.

Representative profile of Pima loam, 75 feet southeast of the northwest corner of sec. 18, T. 16 S., R. 26 E.; at the south end of a sump trench:

Ap1—0 to 4 inches, brown (10YR 5/3) loam, dark brown (7.5YR 3/2) when moist; weak, medium and thick, platy structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine roots; few fine tubular pores; slightly effervescent; moderately alkaline; abrupt, smooth boundary.

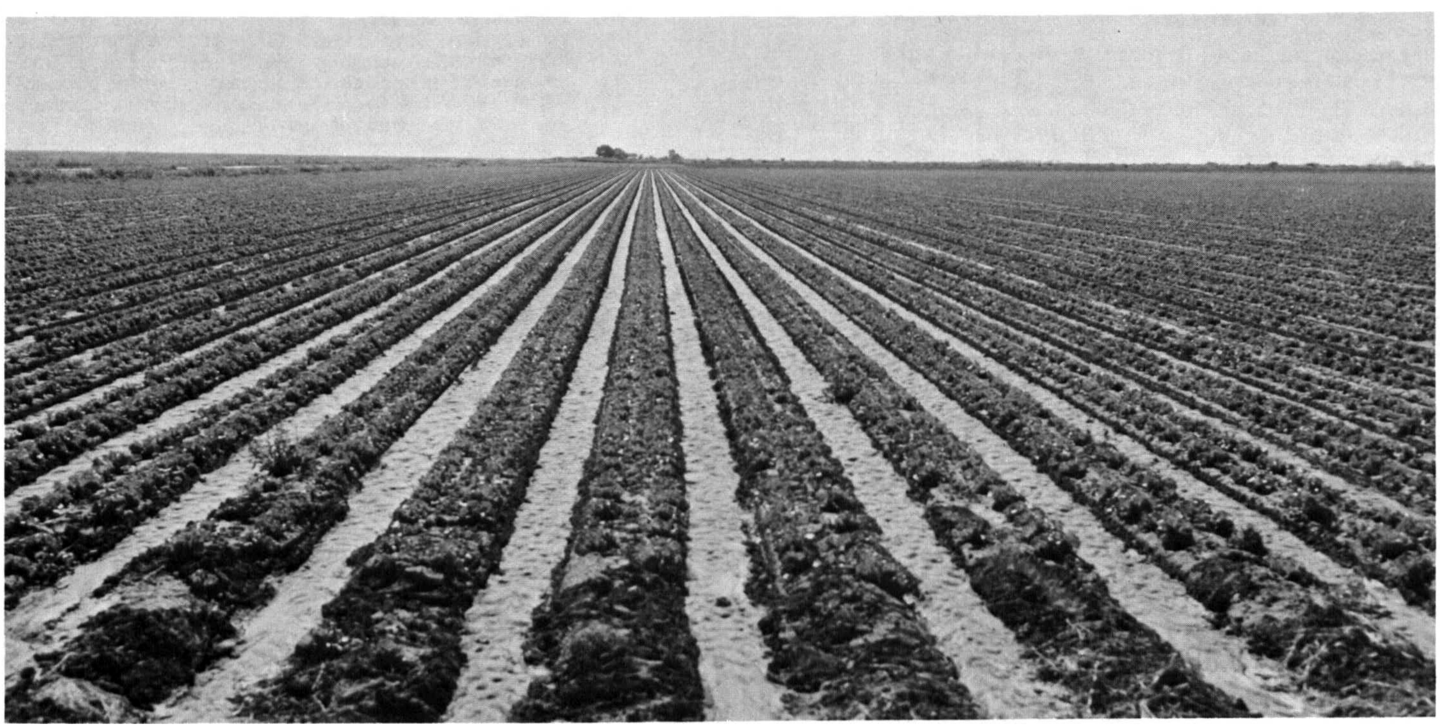

Figure 3.—Irrigated lettuce on McAllister loam. Proper design and leveling allow more even distribution and efficient use of irrigation water.

Ap2—4 to 14 inches, grayish-brown (10YR 5/2) clay loam, dark brown (7.5YR 3/2) when moist; massive; slightly hard when dry, firm when moist, sticky and plastic when wet; many fine roots; common fine tubular pores; moderately alkaline; slightly effervescent; abrupt, smooth boundary.

A13—14 to 30 inches, brown (7.5YR 5/2) silty clay loam, dark brown (7.5YR 3/2) when moist; weak, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many fine roots; common fine tubular pores; slightly effervescent; moderately alkaline; abrupt, smooth boundary.

C—30 to 60 inches, light-brown (7.5YR 6/4) heavy loam, brown (7.5YR 5/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few fine roots; common fine and very fine tubular pores; strongly effervescent; moderately alkaline.

The A horizon ranges from dark grayish brown to brown. It is loam, silt loam, silty clay loam or clay loam and ranges from mildly alkaline to moderately alkaline and from slightly effervescent to strongly effervescent. The C horizon is loam, silt loam, or heavy loam. In places it has thin strata of sandy loam and fine sandy loam that are commonly below a depth of 40 inches. In places lime filaments are in the lower part of the A horizon and in the C horizon.

Pima loam (Pm).—This soil has slopes that are dominantly 0.1 to 0.5 percent. Areas are long and narrow or irregular in shape and are about 60 acres in size.

Included with this soil in mapping are scattered areas of Elfrida silty clay loam, Guest clay loam, and Grabe loam and areas of Forrest loam, Tubac sandy loam and sandy clay loam, Sonoita sandy loam, and Comoro sandy loam on slightly higher positions. The included soils make up about 20 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops, as range, and for homesites and other community developments. Capability units I–1, irrigated, VIc–1, dryland; Loam Bottom range site.

Pridham Series

The Pridham series consists of deep, somewhat poorly drained soils on low fans and valley plains. These soils formed in alluvium derived from mixed sources that include acid and basic, igneous and sedimentary rocks. Slopes are 0 to 2 percent, but in places the surface has uneven microrelief. Elevation is 4,200 to 4,500 feet. The vegetation is alkali sacaton, blue grama, tobosa, annual grasses, and scattered mesquite. Cattails, sedges, and watercress occur in the wetter areas.

In a representative profile the surface layer is gray loam about 5 inches thick. The subsoil is alkali-affected grayish-brown and light brownish-gray clay about 20 inches thick. The substratum is mottled, pale-yellow, grayish-brown, light brownish-gray, and brown clay loam about 12 inches thick. Below this is light-gray and brown clay loam that extends to a depth of 60 inches or more. The profile is moderately alkaline in the surface layer and strongly alkaline below.

The water table fluctuates between depths of 0 and 20 inches early in spring and in midsummer after storms. This fluctuation is the result of subsurface runoff from higher lying soils. The water table drops rapidly to a depth below 5 feet after these periods. In abnormally dry years the soils are dry. In cultivated areas the water table has been lowered by drainage ditches that have intercepted laterally flowing water. Permeability is slow. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used as range and for irrigated crops.

Representative profile of Pridham loam, 200 feet east and 2,600 feet south of the northwest corner of sec. 16, T. 17 S., R. 27 E.:

Ap—0 to 5 inches, gray (10YR 5/1) loam, very dark gray (10YR 3/1) when moist; weak, very fine and fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine, fine, and medium roots; many fine vesicular pores; moderately alkaline; abrupt, smooth boundary.

B21t—5 to 11 inches, grayish-brown (10YR 5/2) clay, very dark grayish brown (10YR 3/2) when moist; weak, medium, prismatic structure parting to moderate, medium, subangular and angular blocky; very hard when dry, friable when moist, sticky and plastic when wet; common very fine, fine, and medium roots; few fine tubular pores; common thin clay films on faces of peds; slightly effervescent; strongly alkaline; clear, smooth boundary.

B22t—11 to 18 inches, grayish-brown (10YR 5/2) clay, very dark grayish brown (10YR 3/2) when moist; few, fine, faint, light yellowish-brown (10YR 6/4) mottles, dark yellowish brown (10YR 4/4) when moist; moderate, fine, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; common very fine, fine, and medium roots; few fine tubular pores; common thin clay films on faces of peds; few, fine, light-gray (10YR 7/2), soft masses of lime; strongly effervescent; strongly alkaline; clear, wavy boundary.

B23t—18 to 25 inches, light brownish-gray (10YR 6/2) clay, dark grayish-brown (10YR 4/2) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common very fine, fine, and medium roots; common thin clay films on faces of peds; common, fine, light-gray (2.5Y 7/2), soft masses of lime, grayish brown when moist; strongly effervescent; strongly alkaline; clear, wavy boundary.

C1ca—25 to 37 inches, mottled pale-yellow (5Y 7/3), grayish-brown (2.5Y 5/2), light brownish-gray (2.5Y 6/2 and 10YR 6/2), and brown (7.5YR 5/4) clay loam, pale olive (5Y 6/3), very dark grayish brown (2.5Y 3/2), grayish brown (2.5Y 5/2 and 10YR 5/2), and dark brown (7.5YR 4/4) when moist; massive; hard when dry, very friable when moist, sticky and plastic when wet; common very fine, fine, and medium roots; 10 percent white (10YR 8/2), soft masses of lime; violently effervescent; strongly alkaline; clear, wavy boundary.

B2tcab—37 to 54 inches, mottled brown (7.5YR 5/4) and light-gray (2.5Y 7/2) clay loam, dark brown (7.5 YR 4/4) and grayish brown (2.5Y 5/2) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; few, fine, black (N 2/0) manganese concretions; common manganese stains on faces of peds; 10 percent white (10YR 8/2), soft masses of lime; violently effervescent; strongly alkaline.

The A1 horizon ranges from gray to grayish brown. It is loam, clay loam, silt loam, or sandy loam and is neutral to strongly alkaline. The B horizon is clay or heavy clay loam. It is strongly alkaline to very strongly alkaline. Mottled horizons are at a depth of less than 20 inches. The C horizon is clay loam, clay, sandy clay loam, or loam. It is moderately alkaline to very strongly alkaline. Depth to the lime (ca) horizon ranges from 11 to 40 inches, but it is dominantly about 15 to 30 inches. The buried Bt horizon in some profiles is not present within 5 feet of the surface.

Pridham loam (Pr).—This soil has slopes that are

dominantly 0.1 to 0.5 percent. Areas are oval and are about 250 to 300 acres in size.

Included with this soil in mapping are areas where the surface layer is sandy loam. These areas are on small mounds and are shown on the soil map by the symbol for sand. Also included are small, scattered areas of Cogswell clay loam, alkali, and Guest loam; undrained areas of a soil similar to Pridham soils but without a water table; and areas of Tubac sandy clay loam, 0 to 2 percent slopes, on slightly higher positions. The included soils make up about 20 percent of the mapped areas. Runoff is slow, and the hazard of erosion is slight.

This soil is used as range and for irrigated crops. Capability units IVw–9, irrigated, VIw–1, dryland; Seepland range site.

Sonoita Series

The Sonoita series consists of deep, well-drained soils on alluvial fans and valley slopes. These soils formed in mixed alluvium derived from coarse-grained, acid, igneous rocks. Slopes range from 0 to 5 percent. Elevation is 4,200 to 4,600 feet. The vegetation is Rothrock grama, blue grama, black grama, three-awn, burroweed, and scattered yucca and mesquite.

In a representative profile the surface layer is brown sandy loam about 9 inches thick. The subsoil is yellowish-red, reddish-brown, and reddish-yellow gravelly sandy loam and sandy loam about 44 inches thick. The substratum is very gravelly sand to a depth of 60 inches or more. The profile is medium acid to slightly acid in the surface layer and ranges to moderately alkaline in the substratum.

Permeability is moderately rapid. Available water capacity is moderate or low. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops, as range, and for homesites and other community developments.

Representative profile of Sonoita sandy loam, 0 to 2 percent slopes, 2,400 feet east and 1,300 feet north of the southwest corner of sec. 21, T. 15 S., R. 26 E.:

A1—0 to 2 inches, brown (7.5YR 5/4) sandy loam, dark reddish brown (5YR 3/4) when moist; weak, thin, platy structure; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; many fine and medium roots; common very fine and fine tubular pores; medium acid; abrupt, smooth boundary.

A3—2 to 9 inches, brown (7.5YR 5/4) sandy loam, dark reddish brown (5YR 3/4) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; many fine and medium roots; many very fine and fine and few medium tubular pores; slightly acid; clear, smooth boundary.

B21t—9 to 17 inches, reddish-brown (5YR 5/4) sandy loam, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and medium roots; many fine and medium tubular pores; common thin clay bridges between sand grains and clay films in pores; mildly alkaline; gradual, smooth boundary.

B22t—17 to 29 inches, reddish-brown (5YR 5/4) sandy loam, reddish brown (5YR 4/4) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine and fine roots; many very fine and fine tubular pores; common thin clay bridges between sand grains and clay films in pores; 10 percent fine gravel; mildly alkaline; clear, wavy boundary.

B23t—29 to 36 inches, reddish-brown (5YR 5/4) fine gravelly sandy loam, reddish-brown (5YR 4/4) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few very fine roots; many very fine and fine tubular pores; common thin clay bridges between sand grains and clay films in pores; 15 percent fine gravel; moderately alkaline; abrupt, wavy boundary.

B31tca—36 to 46 inches, yellowish-red (5YR 5/6) gravelly sandy loam, yellowish red (5YR 5/6) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many very fine and fine and few coarse tubular pores; many thin clay films in pores; 30 percent gravel, ⅛ inch to 3 inches in size; few thin filaments of lime; slightly effervescent; moderately alkaline; clear, wavy boundary.

B32tca—46 to 53 inches, reddish-yellow (5YR 6/6) gravelly sandy loam, yellowish red (5YR 5/6) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common very fine tubular pores; common thin clay bridges between sand grains and clay films in pores; 30 percent fine gravel; slightly effervescent; moderately alkaline; clear, wavy boundary.

C—53 to 60 inches, reddish-yellow (5YR 6/6) very gravelly sand, yellowish red (5YR 5/6) when moist; massive; hard when dry, very friable when moist, nonsticky and nonplastic when wet; few medium and coarse tubular pores and few very fine interstitial pores; 50 percent fine gravel; slightly effervescent; moderately alkaline.

The A horizon ranges from brown to light reddish brown. It is sandy loam, gravelly sandy loam, or loam and ranges from medium acid to neutral. The B2t horizon is sandy loam, fine gravelly sandy loam, gravelly sandy loam, or light loam. The gravel content is 10 to 35 percent. The B2t horizon ranges from neutral in the upper part to moderately alkaline in the lower part and is massive or has weak, subangular blocky structure. Depth to the Btca horizon ranges from 20 to 48 inches.

Sonoita sandy loam, 0 to 2 percent slopes (SnA).—This soil is on long, somewhat narrow, slightly elevated ridges. Slopes are mainly 0.3 to 1.0 percent. Areas are about 50 to 60 acres in size. This soil has the profile described as representative of the series. Gravel content in the subsoil is 10 to 20 percent.

Included with this soil in mapping are areas of Sonoita sandy loam, 2 to 5 percent slopes; areas of Cowan sandy loam; and a few small areas of Cowan soils that have a surface layer of loamy fine sand. Also included are areas of Tubac sandy loam and sandy clay loam and Forrest sandy loam at the foot of ridges and areas of Comoro sandy loam. The included soils make up about 15 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight. Available water capacity is moderate.

This soil is used for irrigated crops, as range, and for homesites and related community developments. Capability units IIs–7, irrigated, VIs–1, dryland; Sand Upland range site.

Sonoita sandy loam, 2 to 5 percent slopes (SnB).—This soil is mainly on long, narrow side slopes of the larger drainageways. Slopes are 2 to 5 percent. Areas are about 30 to 40 acres in size. This soil has a profile similar to the one described as representative of the series, but the gravel content in the subsoil is 10 to 20 percent.

Included with this soil in mapping are areas of Sonoita sandy loam, 0 to 2 percent slopes; small areas

of a Sonoita soil that has a loam surface layer; areas of Cowan sandy loam on ridgecrests; areas of Tubac and Forrest sandy loams; and areas of Pima loam and Grabe loam and sandy loam in narrow swales and drainageways. The included soils make up 15 percent of the mapped areas.

Runoff is slow to medium, and the hazard of erosion is slight to moderate. Available water capacity is moderate.

This soil is used for irrigated crops and as range. Capability units IIe–7, irrigated, VIe–1, dryland; Sand Upland range site.

Sonoita gravelly sandy loam, 0 to 2 percent slopes (SoA).—This soil has slopes that are mainly 0.5 to 1.5 percent. Areas are short, narrow, and irregular in shape and are about 25 acres in size. This soil has a profile similar to the one described as representative of the series, but the subsoil is 15 to 40 percent gravel, and the gravel content in the subsoil averages 20 to 30 percent.

Included with this soil in mapping are small areas of Sonoita sandy loam, 0 to 2 percent slopes; areas where slopes are short and 2 to 5 percent; small, rounded spots of Bernardino and Forrest sandy loam at slope breaks; areas of Tubac sandy loam on slightly lower positions; and scattered areas of Cowan sandy loam. The included soils make up about 15 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight. Available water capacity is low.

This soil is used for irrigated crops and as range. Capability units IIIs–7, irrigated, VIs–1, dryland; Sand Upland range site.

Stewart Series

The Stewart series consists of shallow and very shallow, somewhat poorly drained, saline-alkali affected soils on low terraces and alkali flats that border large playas. These soils formed in lacustrine sediment and alluvium derived from mixed sources that include acid and basic, igneous rocks. Slopes are dominantly less than 0.5 percent, but in places the surface has uneven microrelief because of soil blowing. Elevation is 4,137 to 4,200 feet. The vegetation is alkali sacaton, inland saltgrass, alkali lovegrass, some scattered mesquite, and annual grasses.

In a representative profile the surface layer is light-gray loam about 6 inches thick. The subsoil is brown fine sandy loam about 3 inches thick. Below this is a light yellowish-brown and light-gray, silica- and lime-cemented hardpan about 13 inches thick. The lower part of the substratum is finely stratified, light-gray and pale-yellow sand or loam that extends to a depth of 60 inches or more. The profile is very strongly alkaline.

Permeability is moderate above the hardpan. Available water capacity is very low. Effective rooting depth is 4 to 20 inches.

These soils are used as range and for homesites and other community developments.

Representative profile of Stewart loam, 2,500 feet east and 850 feet north of the southwest corner of sec. 11, T. 14 S., R 24 E.; 2½ miles southwest of Willcox:

A11—0 to 2 inches, light-gray (10YR 7/2) light loam, grayish brown (10YR 5/2) when moist; moderate, thin, platy structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many fine and medium roots; many fine and medium vesicular pores and few fine tubular pores; slightly effervescent; very strongly alkaline; abrupt, smooth boundary.

A12—2 to 6 inches, light-gray (10YR 7/2) loam, brown (10YR 5/3) when moist; massive; slightly hard when dry very friable when moist, nonsticky and nonplastic when wet; many fine and medium roots; common fine tubular pores; slightly effervescent; very strongly alkaline; abrupt, wavy boundary.

B2—6 to 9 inches, brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and medium roots; few fine tubular pores; few thin clay films in pores; some dark stains on faces of peds; slightly effervescent; very strongly alkaline; abrupt, smooth boundary.

C1sicam—9 to 18 inches, light yellowish-brown (10YR 6/4), silica and lime-cemented hardpan, dark yellowish brown (10YR 4/4) when moist; many, large, distinct, dark-gray (5YR 4/1) coatings, black (10YR 2/1) when moist; few, fine, faint, brownish-yellow (10YR 6/6) veins or root channels, yellowish brown (10YR 5/6) when moist; massive; extremely hard when dry, extremely firm when moist; common very fine and fine roots; many fine and very fine tubular pores below laminated capping; slightly effervescent; very strongly alkaline; clear, wavy boundary.

C2sicam—18 to 22 inches, light-gray (10YR 7/2), silica- and lime-cemented hardpan, dark grayish brown (10YR 4/2) when moist; massive; very hard when dry, very firm when moist; many fine and very fine tubular pores; slightly effervescent; very strongly alkaline; clear, wavy bondary.

C3—22 to 33 inches, light-gray (10YR 7/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and very fine tubular pores; few thin clay films in root channels; slightly effervescent; very strongly alkaline; abrupt, wavy boundary.

C4—33 to 37 inches, light-gray (10YR 7/1, 10YR 7/2, and 2.5Y 7/2), finely stratified very fine sand and loamy sand, grayish brown (10YR 5/2 and 2.5Y 5/2) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many very fine interstitial pores; slightly effervescent; very strongly alkaline; abrupt, wavy boundary.

C5—37 to 42 inches, pale-yellow (5Y 7/3) and light-gray (2.5Y 7/2), finely stratified loam, sandy loam, and loamy sand, olive (5Y 4/3) and dark grayish brown (2.5Y 4/2) when moist; massive; hard when dry, firm to friable when moist, nonsticky and slightly plastic when wet; few fine tubular pores; slightly effervescent; very strongly alkaline; abrupt, wavy boundary.

C6—42 to 51 inches, pale-yellow (5Y 7/3) sand, olive (5Y 5/3) when moist; single grained; loose when dry or moist, nonsticky and nonplastic when wet; common fine interstitial pores; common fine gravel; slightly effervescent; very strongly alkaline; abrupt, wavy boundary.

C7—51 to 60 inches, pale-yellow (5Y 7/3), stratified loamy sand and sandy loam, olive (5Y 5/3) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few gravel; common, large, distinct, white (2.5Y 8/2), soft segregations of lime; slightly effervescent; very strongly alkaline.

The A1 horizon ranges from light gray to very pale brown. It is sandy loam, loam, or silt loam and is strongly alkaline to very strongly alkaline. The B horizon is fine sandy loam, sandy loam, loam, silt loam, or light clay loam. It is strongly alkaline to very strongly alkaline. Depth to the hardpan ranges from 4 to 20 inches. Below the hardpan

the soil is finely stratified and ranges from clay to gravelly sand. In places several, thin, cemented strata, less than 1 inch thick, are in this material. The C horizon is strongly alkaline to very strongly alkaline.

Stewart loam (St).—This soil has slopes that are mainly less than 0.5 percent. Areas are irregular in shape and are about 150 acres in size.

Included with this soil in mapping are areas of Duncan loam, shallow variant, in slightly rounded depressions; areas of Stewart sandy loam; areas of Crot sandy loam near the playa; areas of Gothard loam and Duncan loam; and areas of Comoro sandy loam and Comoro sandy loam, alkali variant, on long, narrow or rounded, slightly elevated ridges. Also included are many playas, less than 2 acres in size, that are bordered on their eastern side by low hummocks. The included soils make up about 20 percent of the mapped areas. Many of the playas acquire a surface covering of white salt crystals after light showers followed by prolonged dry periods. The salt is periodically removed by strong winds.

Runoff is very slow, and the hazard of erosion is slight.

This soil is used as range and for homesites and other community developments. Capability unit VII–s1, dryland; Saline Bottom range site.

Torrifluvents

Torrifluvents (To) are in very narrow bands adjacent to meandering, elongated, intermittent streams. These bands are slightly higher than the adjacent nearly level valley plain. Torrifluvents are frequently flooded, and the materials are reworked. The vegetation is giant sacaton, vine-mesquite, cane beardgrass, side-oats grama, green sprangletop, scattered mesquite, and annual grasses.

In most areas of this mapping unit the soil material consists of finely stratified, thick to thin layers of variable texture. It is dominantly sandy loam, loamy sand, and sand and contains a small amount of gravel.

Runoff is slow. The hazard of water erosion is slight if rainfall is normal, but it is high when the soil is flooded. Depending on the texture of the surface layer, the hazard of soil blowing is slight to moderate.

Torrifluvents are mainly used as range, but small areas are farmed if they are adjacent to or within large areas of desirable cropland. Capability unit VIIw–1, dryland; Loam Bottom range site.

Torriorthents, hummocky

Torriorthents, hummocky (TrC), consists of stabilized dunes and old beach ridges bordering the northeastern, northern, and eastern sides of the Willcox Playa. Slopes range from 1 to 45 percent but are dominantly 2 to 10 percent. The ridges range from 500 feet to a little more than ½ mile in width and from ¼ mile to 2 miles in length. Between the ridges the surface is hummocky, and many blowouts have developed. In places playas 1 to 5 acres in size are between the ridges. The vegetation is four-wing saltbrush, blue grama, alkali sacaton, inland saltgrass, and yucca, which is on sandy ridgetops. It is not so dense near the Willcox Playa as it is in other places.

About 65 percent of this mapping unit is stratified sandy loam and loamy sand. About 25 percent is loamy material that occurs as dunes, generally adjacent to the Willcox Playa. The remaining 10 percent is intermixed material in which the surface layer is loam and clay loam and the underlying, stratified material ranges from clay loam to loamy sand. This material is in blowouts, eroded areas, and low areas around hummocks.

Runoff is slow to rapid, depending on steepness of slope. These areas are generally very unstable, and the hazard of water erosion is high on the steeper side slopes. The ridges and windward slopes are fairly stable, but the hazard of soil blowing is high, particularly from March to May.

Included with this unit in mapping are small, scattered tracts of Gothard loam, Stewart loam, and Crot sandy loam in areas between ridges. The included soils make up about 5 percent of the mapped areas.

Torriorthents, hummocky, is used as range and for homesites. Capability unit VIIe–1, dryland; Hummock Upland range site.

Tubac Series

The Tubac series consists of deep, well-drained soils on alluvial fans and valley slopes. These soils formed in alluvium derived mainly from acid, igneous rock. Slopes range from 0 to 25 percent. Elevation is 4,200 to 4,600 feet. The vegetation is Rothrock grama, blue grama, three-awn, burroweed, scattered yucca and mesquite, and annual grasses.

In a representative profile the surface layer is yellowish-red sandy loam about 12 inches thick. The subsurface layer is light-brown gravelly sandy loam about 4 inches thick. The subsoil is red, yellowish-red, and reddish-yellow clay and clay loam to a depth of 60 inches or more. The surface layer is medium acid to neutral, and the lower part of the subsoil is moderately alkaline.

Permeability is slow. Available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for irrigated crops, as range, and for homesites and other community developments.

Representative profile of Tubac sandy loam, 0 to 2 percent slopes, 1,850 feet north and 1,650 feet west of the southeast corner of sec. 23, T. 17 S., R. 24 E.:

A11—0 to 2 inches, yellowish-red (5YR 5/6) sandy loam, reddish brown (5YR 4/4) when moist; weak, thin, platy structure parting to weak, fine, granular structure; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; many fine and medium roots; common fine vesicular and tubular pores; few fine pebbles; medium acid; abrupt, smooth boundary.

A12—2 to 12 inches, yellowish-red (5YR 5/6) sandy loam, reddish brown (5YR 4/4) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common fine and medium roots; many very fine and fine and few coarse tubular pores; slightly acid; clear, wavy boundary.

A2—12 to 16 inches, light-brown (7.5YR 6/4) gravelly sandy loam, dark brown (7.5YR 4/4) when moist; massive; hard when dry, very friable when moist, nonsticky and nonplastic when wet; few very fine and fine roots; many fine vesicular pores and few fine tubular pores; 20 percent fine (2 to 5 millimeters) pebbles; neutral; abrupt, wavy boundary.

B21t—16 to 24 inches, red (2.5YR 4/6) clay, dark red

(2.5YR 3/6) when moist; strong, medium, prismatic structure; very hard when dry, friable when moist, sticky and very plastic when wet; common very fine and fine roots; few thin clay films on faces of peds; common pressure faces; common dark coatings on faces of peds; moderately alkaline; gradual, wavy boundary.

B22t—24 to 29 inches, red (2.5YR 4/6) clay, dark red (2.5YR 3/6) when moist; strong, medium, prismatic structure; very hard when dry, friable when moist, sticky and very plastic when wet; common very fine and fine roots; few thin clay films on faces of peds; common pressure faces; common dark coatings on faces of peds; approximately 10 percent pebbles; slightly effervescent; moderately alkaline; clear, wavy boundary.

B23tca—29 to 40 inches, red (2.5YR 4/6) clay loam, dark red (2.5YR 3/6) when moist; weak, coarse, prismatic structure; very hard when dry, friable when moist, sticky and plastic when wet; common very fine and fine roots; few fine tubular pores; common pressure faces and dark coatings on faces of peds; few pebbles; strongly effervescent; moderately alkaline; clear, wavy boundary.

B31t—40 to 48 inches, yellowish-red (5YR 5/6) sandy loam, yellowish red (5YR 4/6) when moist; massive; very hard when dry, friable when moist, nonsticky and slightly plastic when wet; few fine roots; few fine tubular pores; many clay coatings and bridges between sand grains; 10 percent fine pebbles; slightly effervescent; moderately alkaline; clear, wavy boundary.

B32t—48 to 60 inches, reddish-yellow (5YR 6/6) gravelly sandy loam, yellowish red (5YR 5/6) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; common thin clay coatings and bridges between sand grains; 20 percent pebbles; slightly effervescent; moderately alkaline.

The A1 horizon ranges from yellowish red to reddish yellow. It is sandy loam, gravelly loam, sandy clay loam, or clay loam and is medium acid to neutral. The A2 horizon ranges from light brown to pinkish gray or pink. It is sandy loam, gravelly sandy loam, loam, or gravelly loam and is slightly acid to neutral. The B2t horizon is neutral to moderately alkaline. Depth to the Bca horizon ranges from 20 to 38 inches. In places weathered bedrock is below a depth of 40 inches.

Tubac sandy loam, 0 to 2 percent slopes (TuA).—This soil is on slightly undulating ridges. Slopes are dominantly 0.2 to 1.0 percent. Areas are long and narrow and about 100 acres in size.

Included with this soil in mapping are areas of Tubac sandy clay loam in swales and shallow drainageways; small, long, narrow side slopes that have gradients of 2 to 5 percent on the edges of the drainageways and swales; scattered areas of Forrest sandy loam; long, narrow, oval areas of Comoro sandy loam and Grabe sandy loam on slight elevated ridges; and small, rounded or oval areas of Sonoita sandy loam on ridgecrests. Also included are areas of soils that have a thick surface layer of sandy loam, indicated by the symbol for sand on the soil map. The included soils make up about 25 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops, as range, and for homesites and related community developments (fig. 4). Capability units IIIs–8, irrigated, VIs–1, dryland; Loamy Upland range site.

Tubac gravelly loam, 10 to 20 percent slopes (TvD).—This soil is on the lower half of foot slopes, below areas of Luzena soils of cone-shaped hills. Slopes are dominantly 10 to 18 percent. Areas are about 45 to 50 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is gravelly loam about 4 inches thick and the upper part of the subsoil is gravelly clay that is underlain by strongly weathered rhyolite at a depth of about 48 inches.

Included with this soil in mapping are small strips of Luzena very cobbly loam, 15 to 30 percent slopes; areas of Tubac sandy loam and Comoro sandy loam on toe slopes; and scattered areas of Luzena gravelly

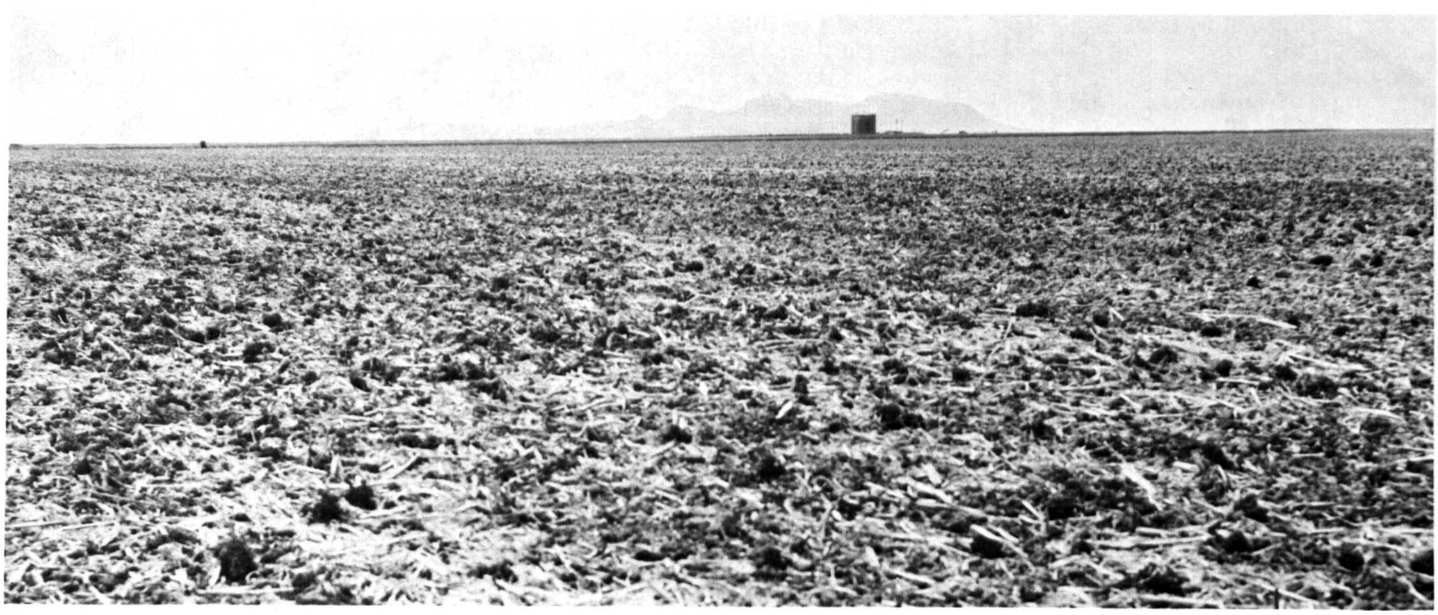

***Figure 4.*—Crop residue from grain sorghum tucked into the soil prevents the loss of topsoil. Soil is Tubac sandy loam, 0 to 2 percent slopes.**

clay loam, 5 to 15 percent slopes. The included soils make up about 10 percent of the mapped areas.

Runoff is medium, and the hazard of erosion is moderate.

This soil is used as range. Capability unit VIe-1, dryland; Loamy Hills range site.

Tubac sandy clay loam, 0 to 2 percent slopes (TwA).—This soil is on slightly undulating ridges. Slopes are dominantly 0.2 to 1.0 percent. Areas are long and narrow and are about 85 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is sandy clay loam about 16 inches thick.

Included with this soil in mapping are small, scattered areas of Tubac sandy loam, 0 to 2 percent slopes; small, long and narrow areas of soils that have slopes of 2 to 5 percent, on side slopes along the edges of drainageways and swales; small, narrow, slightly elevated areas of Comoro sandy loam and Grabe sandy loam, on ridges; and small, rounded or oval areas of Sonoita sandy loam, on ridgecrests. Also included are small areas of Guest clay loam and Pima loam, in drainageways and swales. The included soils make up about 15 percent of the mapped areas.

Runoff is slow, and the hazard of erosion is slight.

This soil is used for irrigated crops and as range. Capability units IIIs-8, irrigated, VIs-1, dryland; Loamy Upland range site.

Vinton Series

The Vinton series consists of deep, well-drained soils on low terraces. These soils formed in alluvium derived from mixed igneous and sedimentary rocks. The surface has been reworked by wind and consists of undulating low dunes. Slopes range from 0 to 5 percent. Elevation is 4,175 to 4,275 feet. The vegetation is sand sagebrush, sand dropseed, bushmuhly, plains bristlegrass, yucca, cholla, and scattered mesquite.

In a representative profile the surface layer is pale-brown loamy sand about 4 inches thick. Below this is stratified, pale-brown, very pale brown, and light-gray loamy fine sand, loamy sand, and fine sand that extends to a depth of 66 inches or more. The profile is neutral to moderately alkaline.

Permeability is moderately rapid. Available water capacity is low. The effective rooting depth is 60 inches or more.

These soils are used as range.

Representative profile of Vinton loamy sand, 600 feet west and 1,600 feet north of the southeast corner of sec. 32, T. 13 S., R. 25 E.:

A1—0 to 4 inches, pale-brown (10YR 6/3) loamy sand, dark brown (10YR 4/3) when moist; weak, thick, platy structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; few fine roots; common fine interstitial pores; neutral; gradual, smooth boundary.

C1—4 to 32 inches, pale-brown (10YR 6/3) loamy fine sand with thin strata (less than 1 inch thick) of fine sandy loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; few fine roots; common fine interstitial pores; mildly alkaline; gradual, smooth boundary.

C2—32 to 50 inches, very pale brown (10YR 7/3) light loamy fine sand, brown (10YR 5/3) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; few fine roots; common fine interstitial pores; mildly alkaline; gradual, smooth boundary.

C3—50 to 60 inches, light-gray (10YR 7/2) fine sand, grayish brown (10YR 5/2) when moist; single grained; loose when dry or moist, nonsticky and nonplastic when wet; few fine roots; many fine interstitial pores; slightly effervescent; moderately alkaline.

The A horizon ranges from grayish brown to pale brown. It is loamy sand or loamy fine sand and is neutral to moderately alkaline and noneffervescent or slightly effervescent. The C horizon is loamy sand, fine sand, or loamy fine sand with thin strata of fine sandy loam or sandy loam. It is neutral to moderately alkaline and noneffervescent or slightly effervescent.

Vinton loamy sand (Vn).—This nearly level to gently sloping and undulating soil is on low, wind-reworked dunes over alluvium. Slopes are dominantly 1 to 3 percent but range from 0 to 5 percent. The area is almost continuous; it is long and somewhat broad and is about 5,000 acres in size.

Included with this soil in mapping are soils on short escarpments that have slopes of as much as 10 percent and long, narrow areas of Crot sandy loam, Gothard sandy loam, Stewart sandy loam, and Dry Lake loamy sand on lower positions. The included soils make up about 10 percent of the mapped areas.

Runoff is slow, and the hazard of water erosion is slight. The hazard of soil blowing is moderate.

This soil is used as range. Capability unit VIe-1, dryland; Sand Upland range site.

Use and Management of the Soils

In this section use and management of the soils in the Willcox Area are discussed. First, use and management of the soils for cultivated crops are described. Then the use of the soils as range and for engineering is discussed.

Cultivated Crops

In this section the system of capability grouping used by the Soil Conservation Service is discussed, the soils in each capability unit are described, and management suited to the soils in each unit is suggested. Also, yields per acre of the principal crops are estimated for those soils in the survey area that are widely used for crops, and the management required to obtain those yields is described.

In the following paragraphs some of the management practices used in the survey area are briefly described.

Conservation cropping system.[3]—A conservation cropping system consists of cultural and management measures needed for optimum crop production. The system selected is influenced by the needs and desires of the farmer, his ability to finance the production of a particular crop, government crop controls, and the effect of the system in controlling diseases, insects, and weeds and in maintaining tilth. In a small part of the survey area, erosion control must be considered in planning a conservation cropping system.

Minimum tillage.—Many of the soils in the survey

[3] By ARNOLD NOWOTNY, conservation agronomist, Soil Conservation Service.

area are unstable and pulverize easily. Minimum or limited tillage is practiced on many farms to lower costs of operation, to improve tilth, and to obtain better water intake. If the finer textured soils are worked when they are wet, a plowpan is likely to form. Care should also be taken to avoid pulverizing the soils when dry. Tillage should vary in depth to prevent the formation of a plowpan.

Crop residue use.—Many of the farms in the survey area are in continuous grain sorghum production. To maintain good crop production, the incorporation of crop residue is necessary. This improves water intake and available water capacity, increases soil aeration, improves soil structure, and increases the number of soil micro-organisms that add plant nutrients. Residue should be incorporated into the soil as soon after harvest as practical so that decay can begin as quickly as possible. Crop residue cushions the soil against the shock of tillage.

Soil micro-organisms, which decompose crop residue, require nitrogen. Low yields of following crops can be avoided by applying proper amounts of nitrogen and by incorporating crop residue at the proper time to accomplish decomposition. In some areas, crop residue management is needed to control erosion, particularly soil blowing (fig. 5).

Irrigation water management.—Management of irrigation water requires special attention. Water is supplied from deep wells. It is generally of good quality, but the quantity available is variable. Because of the small quantity in many areas, special attention should be given to the distribution system of pipelines or concrete ditches and to field leveling. Irrigation ponds and pumpbacks are commonly part of these systems (fig. 6).

Most of the farms are furrow or row irrigated, some fields in alfalfa are bordered and corrugated, and some areas are sprinkled. Attention should be given to the kind of crop and the soil to be irrigated. Efficient irrigation adjusts to the needs of the crop, the soil-moisture relationship at the time of irrigation, the slope of the field, the length of irrigation runs, the time it takes to apply the water, the intake rate of the soil, and other factors that may be significant at the specific time of irrigation, such as depth of furrow, organic-matter content, and weather.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, trees, or engineering.

In the capability system, the kinds of soils are

***Figure 5.*—Result of leaving Karro loam unprotected during windy season. Topsoil accumulates in the ditch to the left.**

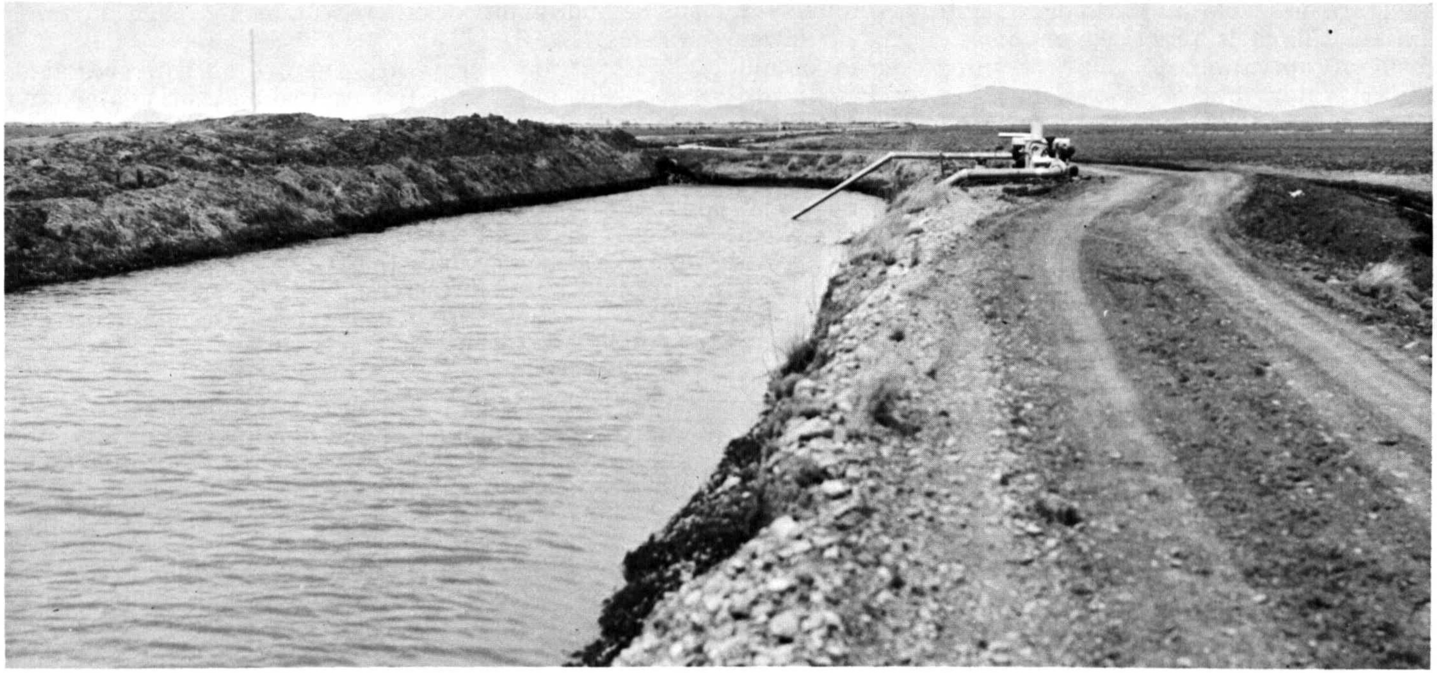

Figure 6.—**Irrigation tailwater recovery pond and pumpback system makes more efficient use of water.**

grouped at three levels: the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife (None in the Willcox Area).

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or to esthetic purposes (None in the Willcox Area).

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in the Willcox Area but not in all parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS in Arizona are given Arabic numbers that suggest the chief kind of limitation responsible for placement of the soil in the capability class and subclass. For this reason, some of the units within the subclasses are not numbered consecutively, and their symbols are a partial key to some of the soil features. The numbers used to designate units in classes I through V are—

1. Surface layer and subsoil texture ranges from medium to moderately fine.
2. Limitation or problem caused by moderately coarse textured surface layer.
3. Limitation or problem caused by fine textured or very fine textured surface layer.

4. Limitation or problem caused by coarse-textured surface layer.
5. Limitation or problem caused by limited effective depth for root development.
6. Limitation or problem caused by coarse fragments in the profile.
7. Limitation or problem caused by limited available water capacity.
8. Limitation or problem caused by slow or very slow permeability of the subsoil or substratum.
9. Limitation or problem caused by the presence of salt or alkali, or both.

The numbers used to designate units within classes VI through VIII are not connotative.

Management by capability units [4]

On the following pages the capability units in the Willcox Area are described and suggestions for use and management of the soils are given. The soils in each unit are listed in the "Guide to Mapping Units" at the back of this survey.

The soils in the dryland capability units are limited by a lack of irrigation water. For specific management practices see the appropriate range site in the section "Range."

CAPABILITY UNIT I-1, IRRIGATED

This unit consists of well-drained soils of the Elfrida, Grabe, McAllister, and Pima series. The surface layer is sandy loam, loam, or silty clay loam. Slopes are 0 to 2 percent.

Permeability is moderately slow to moderate, runoff is slow, and available water capacity is high. Effective rooting depth is 60 inches or more. The hazards of erosion and soil blowing generally are slight, but the hazard of soil blowing is moderate on the Grabe soil.

These soils are used mainly for irrigated crops. They are suited to all crops commonly grown in the survey area. The main crops are grain sorghum, corn, wheat, barley, cotton, sugar beets, lettuce, and alfalfa (fig. 7).

Useful conservation treatments include conservation cropping systems and irrigation water management. Row crops can be grown often if crop residue is returned to the soil. Leveling these soils to a uniform grade is required for efficient irrigation. During land leveling cuts should be limited to a maximum of 8 to 10 inches in Elfrida and McAllister soils to avoid exposing the limy horizon. Careful attention should be given to soil moisture needs in the upper 12 inches of the Grabe soil.

CAPABILITY UNIT IIe-7, IRRIGATED

Only Sonoita sandy loam, 2 to 5 percent slopes, is in this unit. This soil is well drained. The subsoil is gravelly sandy loam. Slopes are 2 to 5 percent.

Permeability is moderately rapid, runoff is medium, and the available water capacity is moderate. Effective rooting depth is 60 inches or more. The hazard of erosion is slight to moderate.

This soil is used for grain sorghum, corn, wheat, barley, cotton, sugar beets, lettuce, and alfalfa.

The organic-matter content of this soil is relatively low, and therefore, making good use of crop residue is important. Conservation treatments include simple erosion-control measures, such as dikes and diversions; conservation cropping systems; and irrigation water management. Frequent light irrigation, using a small head of water, is important to minimize soil losses and to offset the moderate available water capacity.

[4] By ARNOLD NOWOTNY, conservation agronomist, and DAVIE L. RICHMOND, soil scientist, Soil Conservation Service.

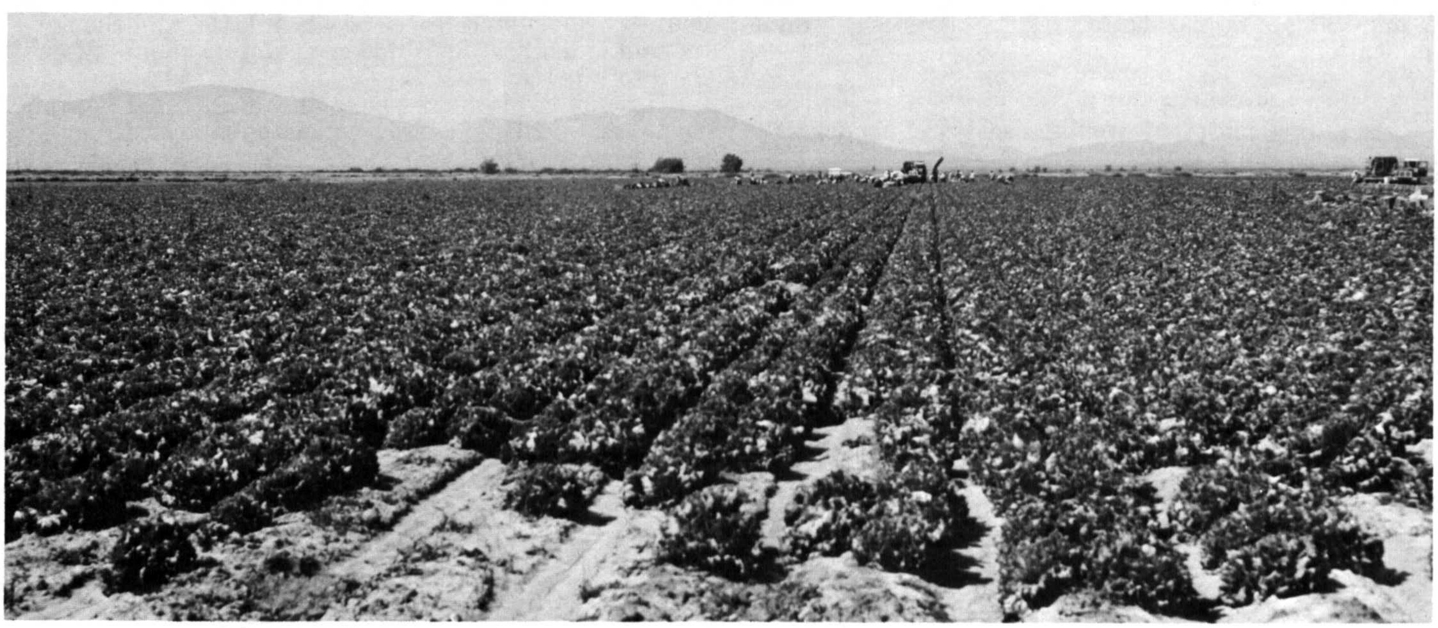

Figure 7.—Lettuce harvest on Pima clay loam. This soil can produce 750 cartons per acre.

CAPABILITY UNIT IIs-7, IRRIGATED

This unit consists of well-drained, calcareous soils of the Comoro, Karro, and Sonoita series. The surface layer is sandy loam or loam. Slopes are 0 to 2 percent.

Permeability is moderately slow to moderately rapid, runoff is slow or very slow, and available water capacity is moderate or high. Effective rooting depth is 60 inches or more. The hazard of erosion is slight, but the sandy loam soils in this unit are susceptible to soil blowing.

These soils are used for grain sorghum, corn, wheat, barley, cotton, sugar beets, lettuce, and alfalfa. Yields of sugar beets are as much as 30 percent lower on the sandier soils. Yields of grain sorghum are about 25 to 30 percent lower on the soils that have excess lime in their horizons.

These soils have limited available water capacity, and management of irrigation water is important. Such factors as frequency of irrigation and the amount of water used in each application are major concerns. Where the soils have an accumulation of lime in the profile, leveling cuts should be limited to a maximum of 6 to 8 inches.

CAPABILITY UNIT IIIe-7, IRRIGATED

Only Comoro gravelly sandy loam, 5 to 10 percent slopes, is in this unit. This soil is well drained and has a surface layer of gravelly sandy loam.

Permeability is moderately rapid, runoff is medium, and the hazard of erosion is moderate. Available water capacity is low. Effective rooting depth is 60 inches or more.

If cropped, the soil in this unit is best suited to alfalfa and grasses. A sprinkler irrigation system rather than a surface system is more suitable because of the slope and the hazard of erosion. Dikes or diversions are needed to protect this soil from runoff from higher lying soils. Such factors as frequency of irrigation and the amount of water used in each application are major concerns. Frequent applications of fertilizer in small amounts give better results than large single applications.

CAPABILITY UNIT IIIe-8, IRRIGATED

This unit consists of well drained and moderately well drained soils of the Bernardino, Dry Lake, and Forrest series. Most of the soils have a surface layer of gravelly sandy clay loam and gravelly sandy loam, but some have a surface layer of loamy sand. Slopes are 0 to 10 percent.

Permeability is slow, runoff is very slow to medium, and available water capacity is high or moderate. The hazard of water erosion is slight or moderate. The hazard of soil blowing is moderate for soils that have a surface layer of loamy sand. Effective rooting depth is 60 inches or more.

Some areas of these soils are not cropped, because of their slope and position. Others are used principally for grain sorghum, but they are suited to all crops commonly grown in the survey area.

A conservation cropping system, dikes and diversions for erosion control, crop residue use, and irrigation water management are needed. Care must be exercised when irrigating to attain adequate penetration of water into the slowly permeable subsoil and to avoid causing a perched water table. Minimum tillage is important. Varying the depth of tillage prevents the formation of a tillage pan. These soils should be worked only enough to prepare a seedbed. If they are worked when wet, a compacted layer forms that restricts the movement of water. Pulverizing the soils when dry should be avoided, because the soils may become soft and fluffy. If water is applied to the pulverized soils, they will run together and the rate of water intake will be reduced. Protection from soil blowing is needed on the Dry Lake soils. Sprinkler irrigation helps to wet the soils uniformly.

CAPABILITY UNIT IIIs-3, IRRIGATED

This unit consists of well-drained soils of the Cogswell and Guest series. The surface layer is clay. Slopes are 0 to 2 percent.

Permeability is slow, runoff is slow, and available water capacity is high. Effective rooting depth is 60 inches or more. The hazard of erosion is slight.

These soils are suited to all crops commonly grown in the survey area. They are used mainly for grain sorghum, corn, wheat, barley, cotton, sugar beets, lettuce, and alfalfa.

These soils should be worked only enough to prepare a seedbed. If they are worked when wet, a compacted layer forms or the surface layer puddles and restricts the rate of water intake. If the soils are worked when dry, they become soft and fluffy. If water is applied to the pulverized soils, they run together and the rate of water intake is reduced. Rough tillage helps to maintain good tilth. Crop residue should be turned under to maintain the organic-matter content, which helps to improve and maintain soil structure and increases the rate of water intake. Special care should be taken when irrigating to attain water penetration, because permeability is slow.

CAPABILITY UNIT IIIs-5, IRRIGATED

Only Frye sandy loam is in this unit. This soil is well drained. The surface layer is sandy loam, and the substratum is a silica- and lime-cemented hardpan. Slopes are 0 to 2 percent.

Permeability is slow above the hardpan, runoff is slow, and available water capacity is low. Effective rooting depth is 18 to 30 inches. The hazard of erosion is slight.

This soil is used mainly for crops. It is suited to most crops commonly grown in the Area. The soil generally yields about 25 percent less cotton and alfalfa than Forrest and Tubac soils, which do not have a hardpan.

Leveling cuts should not exceed 8 to 10 inches to allow some soil depth for rooting. Timing of water application and the amount of water applied are concerns because of the limited rooting depth and low available water capacity. Varying the depth of tillage prevents the formation of a tillage pan.

CAPABILITY UNIT IIIs-7, IRRIGATED

This unit consists of well-drained soils of the Comoro and Cowan series. The surface layer is sandy loam, gravelly sandy loam, and loamy sand, and the subsoil is gravelly sandy loam and loamy sand. Slopes are 0 to 2 percent.

Permeability is moderately rapid to rapid, runoff is medium, and available water capacity is low. Effective rooting depth is 60 inches or more. The hazard of erosion is slight.

These soils are mainly used for crops. They are suited to all crops commonly grown in the Area, but they produce only moderate yields of sugar beets.

Because available water capacity is low, frequent light irrigations using small amounts of water are needed. Seasonal protection from soil blowing is needed. A conservation cropping system is also needed. Returning crop residue to the soil aids in improving organic-matter content and tilth and in reducing soil blowing. To a limited extent, it increases available water capacity in the upper foot of the soil.

CAPABILITY UNIT IIIs-8, IRRIGATED

This unit consists of well-drained soils of the Cogswell, Forrest, Guest, and Tubac series. The surface layer is clay loam, sandy clay loam, gravelly sandy clay loam, loam, and sandy loam. Slopes are 0 to 2 percent.

Permeability is slow, runoff is slow, and available water capacity is high. Effective rooting depth is 60 inches or more. The hazard of erosion is slight.

These soils are used for crops and as range. They are suited to grain sorghum, corn, wheat, barley, cotton, sugar beets, lettuce, grasses, and alfalfa (fig. 8).

A conservation cropping system, crop residue use, and irrigation water management are needed. Minimum tillage is important. Care must be exercised while irrigating to attain adequate penetration of water because of the slow permeability. Varying the depth of tillage prevents the formation of a tillage pan. These soils should be worked only enough to prepare a seedbed. If they are tilled when wet, a compacted layer forms, which restricts the downward movement of water. Pulverizing the soil when dry should be avoided, because it will become soft and fluffy. When water is applied to the pulverized soil, the soil will run together and the rate of water intake will be reduced.

CAPABILITY UNIT IIIs-9, IRRIGATED

This unit consists of well-drained soils of the Cogswell and McAllister series. The surface layer is strongly alkaline and very strongly alkaline clay loam and loam. Slopes are 0 to 2 percent.

Permeability is moderately slow to slow, runoff is very slow and slow, and available water capacity is moderate to high. Effective rooting depth is 60 inches or more. The hazard of erosion is slight.

These soils are used mainly for crops, but also as range. All climatically adapted, saline and alkali-tolerant crops are grown, but only moderate yields are attained because of the salt and alkali content.

Conservation practices include reducing the toxic salt concentration, using a conservation cropping system, returning crop residue to the soil, and managing irrigation water. Minimum tillage is important. If leveling is needed, onsite investigation is desirable before deep cuts are made.

CAPABILITY UNIT IVw-9, IRRIGATED

Only Pridham loam is in this unit. This soil is somewhat poorly drained. The surface layer is saline-alkali affected loam. Slopes are 0 to 1 percent.

Permeability is slow, runoff is slow, and available water capacity is moderate.

Effective rooting depth is 60 inches or more. The hazard of erosion is slight. A seasonal high water table is at a depth of 3 to 5 feet.

This soil is used for crops and as range. The soil is suited to grain sorghum and grasses, but only

Figure 8.—**Harvesting grain sorghum on Tubac sandy clay loam, 0 to 2 percent slopes. The yield here averages 8,200 pounds per acre.**

moderate yields are attained because of the saline-alkali content.

Drainage, flood protection, reduction of toxic salt concentration, alkali reclamation, and management of irrigation water are needed.

CAPABILITY UNIT VIe-1, DRYLAND

This unit consists of very shallow to deep, moderately well drained or well drained soils. Slopes are nearly level to moderately steep.

Permeability is moderately rapid to slow, runoff is very slow to medium, and available water capacity is very low to high. The hazard of erosion is slight or moderate. The soils are subject to soil blowing, especially where the surface layer is loamy sand or sandy loam.

These soils are used mainly as range. Seeding of depleted range is feasible.

CAPABILITY UNIT VIw-1, DRYLAND

This unit consists of deep, somewhat poorly drained soils. Slopes are nearly level.

Runoff is slow, available water capacity is high, and the hazard of erosion is slight. Permeability is slow.

These soils are used mainly as range. Seeding of depleted range is feasible.

CAPABILITY UNIT VIs-1, DRYLAND

This unit consists of moderately deep and deep soils. Slopes are nearly level.

Permeability is slow to moderately rapid, runoff is slow, and available water capacity is high to low. The hazard of erosion is slight.

These soils are used mainly as range. Seeding of depleted range is feasible.

CAPABILITY UNIT VIc-1, DRYLAND

This unit consists of deep, well-drained soils. Slopes are nearly level.

Permeability is moderate to moderately slow, runoff is slow, and available water capacity is high. The hazard of erosion is slight. The soils that have a surface layer of sandy loam are susceptible to soil blowing.

These soils are used mainly as range. Seeding of depleted range is feasible.

CAPABILITY UNIT VIIe-1, DRYLAND

This unit consists of deep soils on stabilized dunes and old beach ridges. Slopes are short and range from nearly level to steep.

Permeability is moderately rapid to very slow, and runoff is slow to rapid. The hazards of water erosion and soil blowing are high.

These soils are used mainly as range. Seeding is not feasible, because erosion is a hazard on these soils.

CAPABILITY UNIT VIIw-1, DRYLAND

This unit consists of deep to very shallow, somewhat poorly drained, saline-alkali affected soils.

Permeability is slow and very slow, and runoff is slow. Some areas of these soils are frequently flooded. The hazard of erosion is generally slight, but in areas subject to flooding it is high. A seasonal high water table is at a depth of 1 to 5 feet.

These soils are used mainly as range. Seeding is not feasible because of the saline-alkali content.

CAPABILITY UNIT VIIs-1, DRYLAND

This unit consists of very shallow to deep, moderately well drained and well drained, nearly level to moderately steep soils. Some soils are very cobbly or saline-alkali affected.

Permeability is moderate to very slow, runoff is very slow to medium, and available water capacity is high to very low. The hazard of erosion is slight or moderate.

These soils are used mainly as range. Seeding is not considered feasible.

Estimated yields

This section gives estimated yields of the principal irrigated crops grown in the survey area and some of the management practices used to obtain those yields. These estimates are based on observations by soil scientists, on comparisons with similar soils, and on information furnished by farmers. Other information was furnished by crop specialists in the Rural Environment and Assistance Program, the Farmers Home Administration, the Soil Conservation Service, the University of Arizona Agricultural Experiment Station, and the office of the Cochise County Agricultural Agent.

Some of the factors considered in making the estimates were the soil and climatic requirements of the crop and the probable yield and quality of the crop under the moderately high level of management commonly used in the survey area.

The crops listed in table 2 are those that are most commonly grown, and the yields shown are representative of the most extensive area of the soil listed. Special crops and crops grown intermittently on a small acreage are not included. The yields in the table are averages, and in any one year actual yields may be higher or lower than those listed. The yields do not apply to individual parcels of lands, and care is needed in applying the ratings to a specific site.

Information provided in this section on yields and management practices will be most useful immediately upon release of this survey. New developments in crop breeding, use of fertilizer, tillage, and control of insects and diseases will make some information obsolete. New and better practices can always be substituted, and the State and Federal farm advisory services can provide the latest information available.

The management practices commonly used to produce the yields listed in table 2 are—

1. Using adequate irrigation water efficiently.
2. Planting adapted varieties of crops.
3. Choosing a suitable cropping system.
4. Using fertilizer as indicated by past response.
5. Tilling according to improved methods.
6. Returning crop residue to the soil.
7. Controlling weeds, pests, and diseases.

Range[5]

Range consists of soils on which the potential native plant community is made up mainly of grasses, forbs, and shrubs that are of sufficient quality and quantity to justify grazing. In the survey area native grasslands cover about 60 percent of the area, or 200,000 acres.

[5] By W. HARVEY NESSMITH, range conservationist, Soil Conservation Service.

TABLE 2.—*Estimated yields per acre of principal crops under a moderately high level of management* [1]

[Absence of a figure means that that soil is not suited to the crop or that the crop is not generally grown on that soil. Some of the soils that have no yield estimates are not irrigated]

Soil	Grain sorghum	Corn	Wheat	Barley	Cotton (lint)	Sugar beets	Lettuce		Alfalfa
							Spring	Fall	
	Lb	*Bu*	*Bu*	*Bu*	*Lb*	*Tons*	*Ctn*	*Ctn*	*Tons*
Bernardino complex, 0 to 10 percent slopes									
Cave gravelly loam									
Cogswell clay loam	6,000	100	90	104	750	25	700	600	6.5
Cogswell clay loam, alkali	4,800		72	83	600	20			4.5
Cogswell clay	6,000	100	90	104	750	25	700	600	6.5
Comoro sandy loam, 0 to 2 percent slopes	6,000	72	70	79	1,000	18	500	400	7
Comoro gravelly sandy loam, 0 to 2 percent slopes	6,000	72	70	79	1,000	18	500	400	7
Comoro gravelly sandy loam, 5 to 10 percent slopes									
Comoro sandy loam, alkali variant									
Cowan sandy loam	6,000	72	70	79	1,000	18	500	400	7
Crot sandy loam									
Dry Lake loamy sand									4
Duncan loam									
Duncan loam, shallow variant									
Elfrida silty clay loam	7,700	125	110	125	1,000	30	700	600	8
Forrest loam, 0 to 2 percent slopes	8,000	125	100	117	1,000	25	700	600	8
Forrest gravelly sandy clay loam, 0 to 2 percent slopes	8,000	125	100	117	1,000	25	700	600	8
Forrest gravelly sandy clay loam, 2 to 5 percent slopes	8,000	125	100	117	1,000	25	700	600	8
Frye sandy loam	7,400	121	97	113	850	25	700	500	6
Gothard fine sandy loam									
Grabe sandy loam	7,000	118	100	113	1,000	22	700	500	8
Grabe loam	7,000	118	100	113	1,000	22	700	500	8
Guest clay loam	5,800	100	90	104	750	25	700	600	6.5
Guest clay	5,800	100	90	104	750	25	700	600	6.5
Karro loam	4,500	98	75	90	500	25	400	400	4
Kimbrough gravelly loam, 2 to 25 percent slopes									
Kimbrough very cobbly loam, shallow over bedrock variant, 15 to 30 percent slopes									
Luzena gravelly clay loam, 5 to 15 percent slopes									
Luzena very cobbly loam, very cobbly subsoil variant, 15 to 30 percent slopes									
McAllister loam	5,500	98	75	90	500	25	500	400	5
McAllister loam, alkali	4,400	79	60	71	400	20			4
Pima loam	8,000	129	110	125	1,000	30	750	650	8
Pridham loam	4,800		75	90	500	25	500	400	4
Sonoita sandy loam, 0 to 2 percent slopes	6,500	80	80	88	1,000	20	700	500	8
Sonoita sandy loam, 2 to 5 percent slopes	6,500	80	80	88	1,000	20	700	500	8
Sonoita gravelly sandy loam, 0 to 2 percent slopes	6,500	80	80	88	1,000	20	700	500	8
Stewart loam									
Torrifluvents									
Torriorthents, hummocky									
Tubac sandy loam, 0 to 2 percent slopes	8,000	125	100	117	1,000	25	700	600	8
Tubac gravelly loam, 10 to 20 percent slopes									
Tubac sandy clay loam, 0 to 2 percent slopes	8,000	125	100	117	1,000	25	700	600	8
Vinton loamy sand									

[1] Compiled with the assistance of James H. Ditton, office manager, Agricultural Stabilization and Conservation Service, Cochise County; Ernest Jones, Farmers Home Administration; Carmy G. Page, Cochise County Agricultural Agent; and Walter L. Diehl, soil conservationist, Soil Conservation Service.

Raising cattle is the main enterprise. Horses, which are used in ranching operations, also graze the range. In the past, sheep and goats were herded in the valley area, but generally they grazed at the higher elevations outside the survey area.

Rainfall in the Willcox Area is variable, and in dry years the range is quickly overgrazed. Continuous heavy grazing will deplete the range. However, the relatively low palatability of plants on saline and limy soils and the inaccessibility of plants on hills enable these sites to retain much of their original vegetation.

Because moisture is very limited, some areas have continued to deteriorate as much from the diversion of water by roads and cultivation as from overgrazing by livestock. In some areas, rodent populations have increased in range adjacent to cultivated areas and have depleted the range when the cultivated fields are fallow (fig. 9).

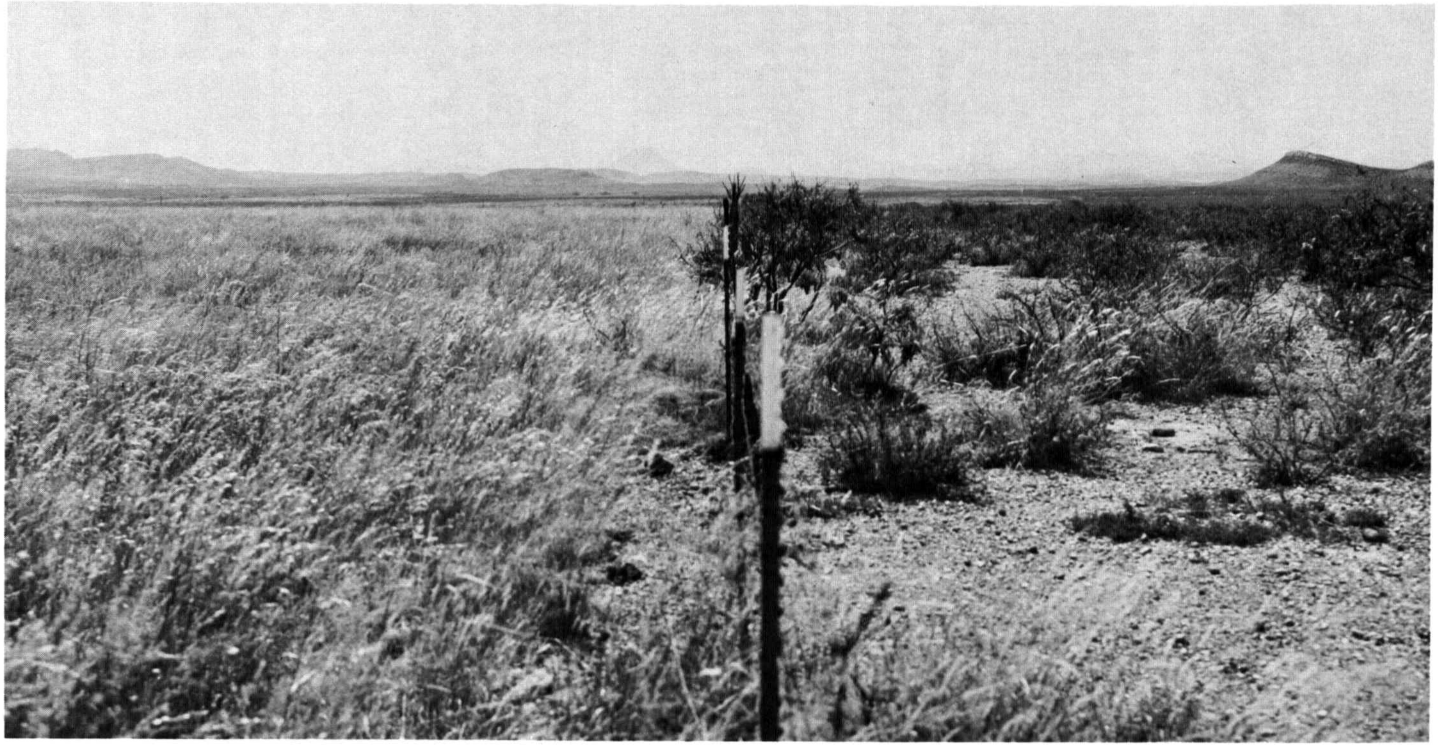

Figure 9.—**Most range can be improved by rootplowing and reseeding, as in seeded area to the left. Area to the right is unseeded. Both areas are Tubac sandy loam, 0 to 2 percent slopes.**

Range sites and condition classes

Different kinds of soil vary in their capacity to produce grass and other plants for grazing. Soils that produce about the same kinds and amounts of forage make up a range site.

Range sites are distinctive kinds of range that differ in their ability to produce vegetation. The soils of any one range site produce about the same kind of climax vegetation. Climax vegetation is the stabilized plant community; it reproduces itself and does not change as long as the environment remains unchanged. Throughout the valley and the foot slopes, the climax vegetation consists of the kinds of plants that were growing when the region was first settled. If cultivated crops are not grown, the most productive combination of forage plants on a range site is generally the climax vegetation.

Four range condition classes are used to indicate the change in the potential, or climax, vegetation that is brought about by grazing or other uses. The classes show the present condition of the vegetation on a range site in relation to the climax vegetation. A range is in *excellent* condition if 76 to 100 percent of the present vegetation is of the same kind as the climax plant community. It is in *good* condition if the percentage is 51 to 75, in *fair* condition if the percentage is 26 to 50, and in *poor* condition if the percentage is less than 25.

Potential forage production depends on the range site. Current forage production depends on the range condition and the amount of moisture available to plants during the growing season.

A primary objective of good range management is to keep range in good or excellent condition. If the range condition is good or excellent, water is conserved, yields are improved, and the soils are protected. Recognizing important changes in the plant cover of a range site is the main concern in management. These changes take place gradually and can be misinterpreted or overlooked. Lush growth encouraged by heavy rainfall may lead to the conclusion that the range is in good condition, when actually the plant cover is weedy and the long-term trend is toward lower production. On the other hand, range that has been closely grazed for short periods, under the supervision of a careful manager, may have a degraded appearance that temporarily conceals its quality and ability to recover.

Descriptions of the range sites

In the following pages, the range sites of the Willcox Area are described and the climax plants and principal invaders on the sites are named. An estimate of the potential annual yield of air-dry herbage for each site when it is in excellent condition is given. The soils of each range site can be determined by referring to the "Guide to Mapping Units" at the back of this survey.

SALINE BOTTOM RANGE SITE

This site (fig. 10) is on valley plains and low lake terraces that border the Willcox Playa. The surface is mostly smooth but has occasional hummocky areas or large, shallow depressions. The soils formed in alluvium derived from a wide variety of parent material. They are very shallow to deep and nearly level and have a surface layer of clay, sandy loam, or fine sandy loam. They are somewhat poorly drained to well drained. Most of the soils are saline-alkali or alkali-affected and

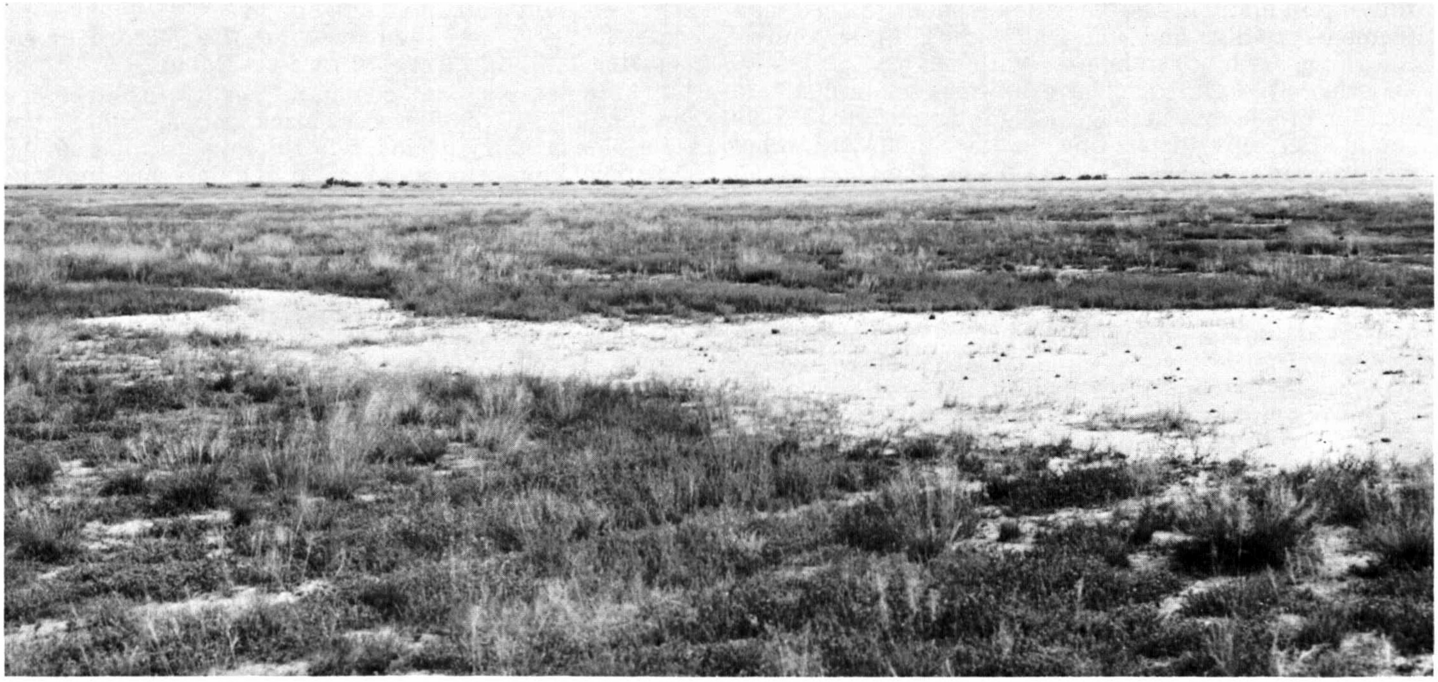

Figure 10.—**Saline Bottom range site in good condition. Vegetation is principally alkali sacaton and saltgrass. The soil has many barren areas and small playas.**

are moderately alkaline to very strongly alkaline. Permeability is slow to very slow. Surface crusting or sealing is common. These soil properties limit the plant species that can grow on this site.

The potential plant community is 25 to 50 percent alkali sacaton, 10 to 25 percent salt lovegrass, 5 to 15 percent tobosa, 5 to 10 percent blue or hairy grama, 5 to 10 percent saltgrass, 5 to 10 percent squirreltail, 5 to 10 percent vine-mesquite, 5 to 10 percent saltbush, and 0 to 5 percent seepweed. The plant community on this site varies with differences in soil texture, salinity, alkalinity, and available moisture. The area closest to the present lakebed is dominated by seepweed and saltgrass. Farther out from the lakebed, alkali sacaton, salt lovegrass, and seepweed dominate; still farther out, where salinity and alkalinity are lower, a great number of species that are less tolerant of saline and alkali conditions are present, such as blue grama, vine-mesquite, and sacaton.

This site has deteriorated less than other sites because of the relative unpalatability of the sharp, coarse vegetation. Some species have been depleted, but the principal species, alkali sacaton and inland saltgrass, have replaced them. In a few places mesquite and goldenrod have invaded, but most of the site is in good condition. Under good range management the more palatable species return slowly. Seeding is not practical.

If this site is in excellent condition, the annual production of air-dry herbage ranges from 1,200 pounds per acre in unfavorable years to 1,700 pounds per acre in favorable years.

SEEPLAND RANGE SITE

This site is on nearly level valley plains and alluvial fans. Areas are generally about 250 to 300 acres in size and may appear hummocky because of a buildup of soil around clumps of alkali sacaton. The soils are somewhat poorly drained and have a surface layer of loam. Permeability is slow. During the wetter months, water seeps out of the soil around fenceposts or around clumps of alkali sacaton.

The vegetation on this site varies with differences in salinity and alkalinity of the water and the depth of the water table. The potential plant community is 15 to 35 percent alkali sacaton, 10 to 30 percent tobosa, 5 to 20 percent bush muhly, 5 to 15 percent red muhly, 5 to 15 percent inland saltgrass, and 5 to 15 percent black grama.

This site does not respond rapidly to management, because alkali sacaton and tobosa occupy areas where more palatable plants formerly grew.

If this site is in excellent condition, the annual production of air-dry herbage ranges from 700 to 1,500 pounds per acre, depending on the amount and the time of seepage received from adjacent areas.

CLAY BOTTOM RANGE SITE

This site is on flood plains and alluvial terraces. The soils formed in alluvium derived from a wide variety of parent material. They are nearly level and deep, have a surface layer of clay or clay loam, and are well drained. Permeability is slow.

The potential plant community is 10 to 30 percent side-oats grama, 10 to 30 percent vine-mesquite, 10 to 25 percent tobosa, 10 to 25 percent giant sacaton, and 5 to 15 percent cane beardgrass.

This site benefits from extra moisture received as runoff from adjacent, higher lying soils or from stream overflow, but its accessibility causes it to deteriorate rapidly. Overgrazing along trails and roads has caused

gullying in many areas. The site responds to good management rapidly; and water spreading, brush control, and range seeding can be used with success.

If this site is in excellent condition, the annual production of air-dry herbage ranges from 700 to 2,000 pounds per acre, depending on the amount of runoff received from adjacent areas and on the steepness of slope.

LOAM BOTTOM RANGE SITE

This site is on flood plains and in swales on low terraces that are subject to occasional overflow. The soils formed in alluvium derived from mixed materials. They are deep and nearly level and have a surface layer of loam or sandy loam. Permeability is moderate.

The potential plant community is 20 to 40 percent giant sacaton, 10 to 30 percent blue grama, 10 to 25 percent side-oats grama, 5 to 10 percent vine-mesquite, 5 to 10 percent cane beardgrass, and 5 to 10 percent green sprangletop.

If this site is grazed throughout the year, most of the palatable plants disappear, and only sacaton and tobosa remain to protect the soils. The site responds rapidly to good management. Water spreading is feasible, and if the site deteriorates to the point that sacaton and tobosa die out, brush control and range seeding are effective means of restoring the site.

If this site is in excellent condition, annual production of air-dry herbage ranges from 700 to 5,800 pounds per acre, depending on the amount of runoff received from adjacent areas and on the steepness of slope.

HUMMOCK UPLAND RANGE SITE

This site is on stabilized dunes and old beach ridges that border the northeastern, northern, and eastern sides of Willcox Playa. The soils are deep, nearly level to steep, stratified sandy loam, sand, and loamy sand. They are saline-alkali affected in places. They have been reworked and deposited by wind. The hazard of soil blowing is high. Permeability is variable.

The potential plant community is 10 to 30 percent bush muhly, 10 to 30 percent black grama, 10 to 30 percent blue or hairy grama, 5 to 10 percent dropseed, 0 to 5 percent four-wing saltbush, 0 to 5 percent sand sagebrush, and 0 to 5 percent bush dalea.

Woody plants and annuals dominate the site as it deteriorates, and sand sagebrush, bush dalea, and mesquite are dominant in most places.

If this site is in excellent condition, the annual production of air-dry herbage ranges from 500 pounds per acre in unfavorable years to 1,700 pounds in favorable years.

SAND UPLAND RANGE SITE

This site (fig. 11) is on flood plains and low terraces that have wind-worked dunes or hummocks in places. The soils formed in mixed alluvium. They are deep and nearly level to moderately sloping and have a surface layer of sandy loam, gravelly sandy loam, or loamy sand. They are well drained or moderately well drained. Permeability is slow to rapid.

The potential plant community is 5 to 30 percent black grama, 5 to 15 percent side-oats grama, 5 to 15 percent bush muhly, 5 to 15 percent bristlegrass, 5 to 15 percent Arizona cottontop, 5 to 15 percent cane beardgrass, 0 to 10 percent three-awn, and 0 to 10 percent spike and sand dropseed.

As the site deteriorates, mesquite and burroweed invade the area.

Most of the site responds rapidly to good management, but the soils that have a sandier surface layer do not respond to management readily, because they tend to be droughty. These soils are also susceptible to soil

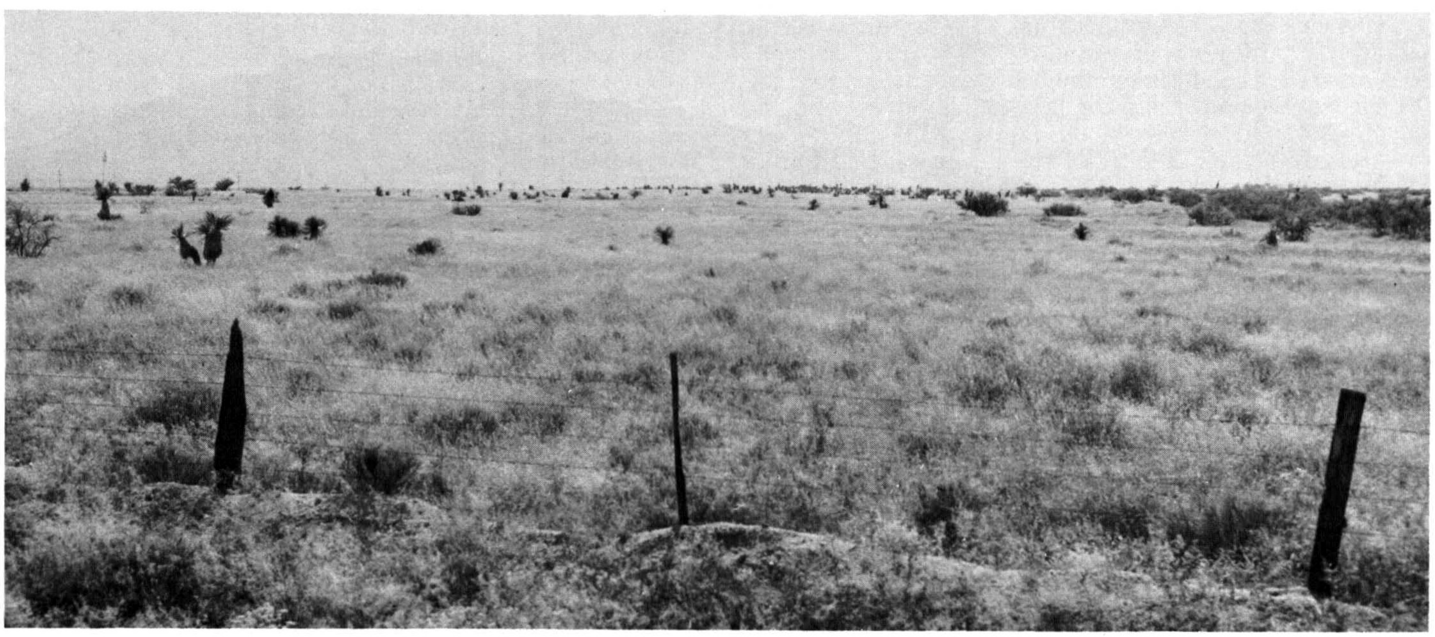

Figure 11.—**Sand Upland range site in fair condition. Dominant vegetation is black grama, burrowweed, and scattered yucca.**

blowing. Efforts should be made to maintain a good plant cover through proper grazing management. The soils that have low available water capacity do not respond to brush control, contour furrowing, pitting, and seeding as well as those that have available water capacity.

If this site is in excellent condition, the annual production of air-dry herbage ranges from 250 pounds per acre in unfavorable years to 1,300 pounds in favorable years.

LOAM UPLAND RANGE SITE

This site is on flood plains and valley plains near old lake margins. It is dissected by drainageways in only a few places. The soils are deep, nearly level, and well drained and have a surface layer of silty clay loam. Permeability is moderately slow.

The potential plant community is 10 to 25 percent side-oats grama, 10 to 25 percent cane beardgrass, 10 to 25 percent black grama, 10 to 25 percent plains lovegrass, and 5 to 20 percent blue grama.

If the plant cover is removed, these soils develop a surface crust, and runoff can cause sheet or gully erosion. When mesquite invades this site, brush control is needed to improve the range. Range seeding after brush control, pitting, or furrowing is successful if the site is protected from grazing until plants are well established.

If this site is in excellent condition, annual production ranges from 400 to 700 pounds per acre, depending on the amount of rainfall and on growing conditions.

LOAMY UPLAND RANGE SITE

This site is on flat, rolling plains, valley plains, and broad alluvial fans. The soils formed mainly in alluvium derived from mixed sources, but some formed in residuum from volcanic rocks. The soils are nearly level to strongly sloping and are very shallow to deep. They have a surface layer of sandy loam to clay loam, which is gravelly in places. Some of the soils are alkali affected in places. Permeability is slow or moderately slow.

The potential plant community is 25 to 50 percent side-oats grama, 10 to 25 percent plains lovegrass, 5 to 30 percent blue and hairy grama, 5 to 10 percent cane beardgrass, 5 to 10 percent curly mesquite, and 5 to 10 percent perennial shrubs.

This site responds rapidly to good management, especially on soils that have a coarse-textured surface layer. Brush, such as mesquite and catclaw, has invaded much of this site, along with burroweed. Brush control, range seeding, pitting, and contour furrowing are feasible.

If this site is in excellent condition, the annual production of air-dry herbage ranges from 500 pounds per acre in unfavorable years to 1,450 pounds in favorable years.

CALICHE UPLAND RANGE SITE

This site is on low foothills and alluvial fans. The soils are nearly level to gently sloping. They are very shallow to shallow and have a surface layer of gravelly loam over an indurated caliche hardpan. Permeability is moderate above the hardpan.

The original plant community consisted of a wide variety of drought-resistant perennial grasses, forbs, and shrubs. The potential plant community is 5 to 35 percent black grama, 5 to 25 percent bush muhly, 5 to 10 percent side-oats grama, 5 to 10 percent plains bristlegrass, 5 to 10 percent hairy grama, 0 to 5 percent rough menodora, and 5 to 10 percent slim tridens.

At least 10 percent of the vegetation on this site is a mixture of shrubs, such as ratany, calliandra, fourwing saltbush, creosotebush, and whitehorn, with traces of bush muhly and black grama in areas where brush protects the plants from grazing. This site responds slowly to good management. Brush control and range seeding are successful.

If this site is in excellent condition, the annual production of air-dry herbage ranges from 400 pounds per acre in unfavorable years to 900 pounds in favorable years.

LIMY UPLAND RANGE SITE

This site (fig. 12) is on valley plains and foothills. The soils are well drained and are very shallow to deep. They are nearly level to moderately steep and have a surface layer of loam, gravelly loam, or very cobbly loam over a lime horizon that is cemented in places. Permeability is moderately slow to moderate.

The original plant community consisted of warm-season grasses and a few shrubs. The potential plant community is 10 to 50 percent side-oats grama, 30 to 40 percent black grama, 10 to 15 percent hairy grama, 5 to 35 percent slim tridens, 5 to 10 percent three-awn, 0 to 5 percent sacahuista, and 0 to 5 percent ephedra.

This site responds to management rapidly. Brush control and reseeding are successful in areas where brush has invaded.

If this site is in excellent condition, the annual production of air-dry herbage ranges from 450 pounds per acre in unfavorable years to 1,000 pounds in favorable years.

LOAMY HILLS RANGE SITE

This site is on hills and foot slopes. The soils formed in mixed alluvium or residuum derived from volcanic rock. The soils are shallow to deep and well drained. They are moderately sloping to moderately steep and have a surface layer of gravelly loam or very cobbly loam. Permeability is slow.

The potential plant community is 25 to 50 percent side-oats grama, 10 to 25 percent plains lovegrass, 10 to 25 percent black grama, 5 to 10 percent sprucetop grama, 5 to 10 percent hairy grama, 5 to 10 percent cane beardgrass, 0 to 10 percent curly mesquite, and 0 to 10 percent calliandra. Century plants and shrub buckwheat are also common on this site.

The steeper slopes and the very cobbly surface layer serve as a deterrent to livestock in pastures that include other range sites. Therefore, most of this site has remained in good condition. The site responds to management rapidly. Grazing distribution is the main concern in management. Additional fencing, livestock trails, and water developments are generally the only structural practices needed.

If this site is in excellent condition, the annual production of air-dry herbage ranges from 700 to 1,400 pounds per acre, depending on the amount of rainfall.

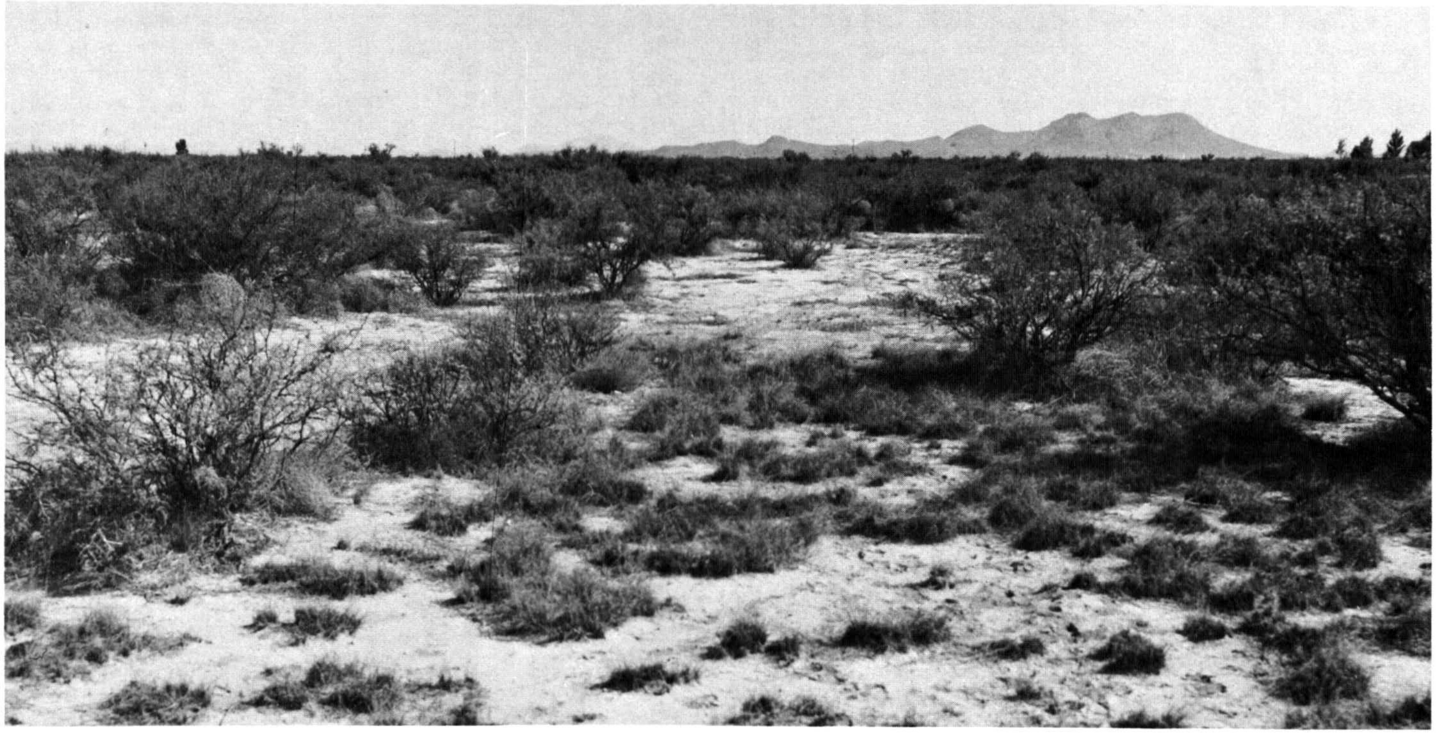

Figure 12.—**Limy Upland range site in poor condition. Sparse vegetation is alkali sacaton and short mesquite.**

Engineering Uses of the Soils [6]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 3, 4, and 5, which show, respectively, several estimated soil properties significant to engineering; interpretations for various engineering uses; and results of engineering laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in table 4, and it also can be used to make other useful maps.

This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists that is not known to all engineers. The Glossary defines many of these terms commonly used in soil science.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system,

[6] BOBBY G. KILCREASE, engineering specialist, Soil Conservation Service, helped to prepare this section.

used by the Soil Conservation Service, the Department of Defense *(14)*, and other agencies, and the AASHO system *(1)*, adopted by the American Association of State Highway Officials.

The Unified system is used to classify soils according to particle-size distribution, plasticity, liquid limit, and organic-matter content and are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, CL–ML.

The AASHO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHO classification for tested soils, with group index numbers in parentheses, is shown in table 5; the estimated classification, without group index numbers, is given in table 3 for all soils mapped in the survey area.

Soil properties significant to engineering

Several estimated soil properties significant in engineering are given in table 3. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the columns in table 3.

Engineers and soil scientists have classified the soil series in the survey area into four hydrologic groups. These hydrologic groups are used for estimating the runoff potential of soils on watersheds. The grouping indicates the minimum rate of infiltration on bare soil at the end of individual storms occurring after the soil has had prolonged wetting and opportunity for swelling. Slope, cover, storm intensity, and other related factors are considered when the soil groups are used by hydrologists. The four groups are:

Group A soils have a high infiltration rate when thoroughly wetted. They consist chiefly of deep, well-drained to excessively drained sand or gravel, or both. These soils have a high rate of water transmission and have low runoff potential.

Group B soils have a moderate infiltration rate when thoroughly wetted. They consist of moderately deep to deep, moderately well drained to well drained soils that have moderately fine to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C soils have a slow infiltration rate when thoroughly wetted. They consist of soils that have a layer that impedes the downward movement of water or soils that have moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission.

Group D soils have a very slow infiltration rate when thoroughly wetted. They consist of (1) clay soils that have a high swelling potential, (2) soils that have a high permanent water table, (3) soils that have a claypan or clay layer at or near the surface, and (4) soils that are shallow over nearly impervious materials. These soils have a very slow rate of water transmission.

Depth to hardpan or bedrock is the distance from the surface of the soil to the upper surface of the rock or hardpan layer.

Soil texture is described in table 3 in standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from the semisolid to plastic state; and the liquid limit, from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of soil characteristics observed in the field, particularly structure and texture. The estimates in table 4 do not take into account seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed as pH. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content; that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils cause much damage to building foundations, roads,

TABLE 3.—*Estimated soil*

[The symbol > means greater

Soil series and map symbols	Hydrologic group	Depth to hardpan or bedrock	Depth from surface	USDA texture	Classification		Coarse fraction greater than 3 inches
					Unified	AASHO	
		Feet	*Inches*				*Percent*
Bernardino: BeC	C	>5	0–4½	Gravelly sandy loam	GM	A–2, A–1	0
			4½–32	Gravelly clay	CH	A–7	0
			32–56	Gravelly sandy clay loam and sandy clay loam.	SC	A–7	0
Cave: Ca	D	1–1½	0–11	Gravelly loam	GM	A–4, A–2	0–5
			11–25	Lime-cemented hardpan			
Cogswell: Cc, Cg	C	>5	0–12	Clay loam	CL, CH	A–6, A–7	0
			12–26	Clay	CH	A–7	0
			26–60	Clay loam	CL	A–6	0
Ce	C	>5	0–3	Clay loam	CL	A–6	0
			3–29	Clay	CH	A–7	0
			29–54	Sandy clay loam and sandy loam.	SC	A–6	0
Comoro: CmA, CnA, CnC	B	>5	0–37	Sandy loam and fine gravelly sandy loam.	SM	A–2	0
			37–60	Fine gravelly loamy sand	SM	A–2, A–1	0
Comoro variant: Co	B	>5	0–36	Sandy loam	SM	A–2	0
			36–49	Light clay loam	CL	A–6	0
			49–72	Very gravelly sand	SP	A–1	0
Cowan: Cs	A	>5	0–60	Sandy loam and loamy sand	SM	A–2	0
Crot: Ct [2]	D	>5	0–5	Sandy loam	SM	A–2	0
			5–17	Sandy clay loam	SC	A–6	0
			17–60	Finely stratified sand to silt loam.	SM	A–2	0
Dry Lake: Dr	C	>5	0–24	Loamy sand	SM	A–2	0
			24–60	Heavy loam	ML	A–4	0
Duncan: Du	D	1½–3½	0–5	Loam	ML	A–4	0
			5–35	Clay	CH	A–7	0
			35–40	Silica and lime-cemented hardpan.			
			40–60	Gravelly clay loam and clay loam.	CL	A–6	0
Duncan variant: Dv	D	½–1½	0–13	Loam and clay	CL	A–7	0
			13–23	Silica and lime-cemented hardpan.			
			23–48	Clay and sandy clay loam	SC, CL	A–6	0
			48–68	Very fine sandy loam	ML	A–4	0
Elfrida: Ef	B	>5	0–60	Stratified heavy loam, clay loam, and silty clay loam.	CL	A–6	0
Forrest: FoA, FrA, FrB	C	>5	0–29	Gravelly sandy clay loam, clay loam, or heavy loam and clay.	CH	A–7	0
			29–60	Clay loam and loam	CL	A–6	0
Frye: Fy	C	1½–2½	0–12	Sandy loam and loam	SM	A–2	0
			12–26	Clay	CH	A–7	0
			26–38	Silica and lime-cemented hardpan.			
			38–80	Loam	CL	A–6	0

properties significant to engineering

than; < means less than]

Percentage less than 3 inches passing sieve—				Atterberg values		Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	Liquid limit	Plasticity index					Zinc-coated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
50–65	45–60	30–40	15–30	--------	[1] NP	2.0–6.0	0.07–0.09	7.4–8.4	Low	High	Low.
65–80	60–75	65–70	50–60	55–65	30–40	0.06–0.2	0.11–0.13	7.4–8.4	High	High	Low.
75–90	70–85	50–65	30–40	30–40	15–25	0.6–2.0	0.13–0.15	7.9–8.4	Moderate	High	Low.
60–75	55–70	45–60	30–50	25–35	NP	0.6–2.0	0.12–0.14	7.9–8.4	Low	High	Low.
--------	--------	--------	--------	--------	--------	<0.06	--------	--------	--------	--------	
95–100	95–100	85–100	60–80	35–55	15–30	0.2–0.6	0.19–0.21	7.4–8.4	Moderate or high.	High	Low.
95–100	95–100	90–100	85–95	65–80	45–55	0.06–0.2	0.14–0.16	7.9–8.4	High	High	Low.
95–100	95–100	85–95	70–80	30–40	15–25	0.2–0.6	0.19–0.21	7.9–9.0	Moderate	High	Low.
95–100	95–100	85–100	60–80	30–40	15–25	0.2–0.6	0.15–0.17	8.5–9.6	Moderate	High	High.
95–100	95–100	90–100	85–95	65–80	45–55	0.06–0.2	0.11–0.13	8.5–9.6	High	High	High.
95–100	95–100	80–90	35–50	30–40	10–15	0.2–0.6	0.11–0.13	8.5–9.6	Moderate	High	High.
90–100	70–95	50–70	25–40	--------	NP	2.0–6.0	0.08–0.13	6.6–8.4	Low	High	Low.
85–100	60–80	40–55	15–25	--------	NP	6.0–20.0	0.05–0.07	7.4–8.4	Low	Moderate	Low.
95–100	90–100	60–75	30–45	--------	NP	2.0–6.0	0.11–0.13	7.4–9.6	Low	Low	Low.
85–100	85–100	80–100	60–80	30–40	10–20	0.06–0.2	0.15–0.17	8.5–9.6	Moderate	High	High.
70–80	35–50	20–30	0–5	--------	NP	6.0–20.0	0.03–0.04	8.5–9.6	Low	High	High.
95–100	90–100	50–75	20–35	--------	NP	2.0–6.0	0.08–0.11	6.6–8.4	Low	Moderate	Low.
100	100	60–70	25–35	--------	NP	2.0–6.0	0.09–0.11	7.8–9.6	Low	High	Low.
100	100	65–75	35–45	35–40	15–25	<0.06	0.11–0.13	8.5–9.6	Moderate	High	Moderate.
90–100	80–100	60–70	15–35	--------	NP	0.2–0.6	0.09–0.11	8.5–9.6	Low	High	High.
100	100	50–75	15–30	--------	NP	6.0–20.0	0.06–0.08	7.9–8.4	Low	Moderate	Low.
95–100	90–95	85–95	60–75	30–40	5–10	0.06–0.20	0.13–0.15	8.5–9.6	Low	High	High.
100	100	85–95	60–75	30–40	5–10	0.2–0.6	0.13–0.15	8.5–9.6	Low	High	High.
100	100	90–100	75–95	50–60	25–35	<0.06	0.11 0.13	8.5–9.6	High	High	High.
--------	--------	--------	--------	--------	--------	<0.06	--------	--------	--------	--------	
85–95	70–90	65–80	50–70	30–40	10–20	<0.06	--------	7.8–9.6	Moderate	High	High.
100	100	90–95	70–80	40–50	20–25	0.06–0.2	0.13–0.15	8.5–9.6	High	High	High.
--------	--------	--------	--------	--------	--------	<0.06	--------	--------	--------	High	High.
100	90–100	80–90	45–60	40–50	25–30	<0.06–0.2	--------	8.5–9.6	Moderate	High	High.
100	100	95–100	60–70	30–40	NP–5	0.6–2.0	--------	8.5–9.6	Low	High	High.
95–100	90–100	85–95	60–80	30–40	15–25	0.2–0.6	0.16–0.21	7.4–8.4	Moderate	High	Moderate.
75–100	70–100	65–95	50–85	55–65	25–40	0.06–0.2	0.14–0.16	6.1–8.4	High	High	Low.
95–100	85–95	70–80	55–65	30–40	15–25	0.2–2.0	0.16–0.21	7.9–8.4	Moderate	High	Moderate.
90–100	85–95	60–70	25–35	--------	NP	0.6–6.0	0.11–0.18	6.1–8.4	Low	Low	Low.
95–100	90–100	80–90	70–80	70–80	50–60	0.06–0.2	0.14–0.16	7.9–9.0	High	High	Moderate.
--------	--------	--------	--------	--------	--------	<0.06	--------	--------	--------	--------	--------
95–100	85–95	70–80	55–65	20–30	NP–5	0.6–2.0	--------	7.9–8.4	Low	High	Moderate.

TABLE 3.—*Estimated soil properties*

Soil series and map symbols	Hydrologic group	Depth to hardpan or bedrock	Depth from surface	USDA texture	Classification		Coarse fraction greater than 3 inches
					Unified	AASHO	
		Feet	*Inches*				*Percent*
Gothard: Go	D	>5	0–5	Fine sandy loam	SM	A–4	0
			5–42	Clay loam and heavy loam	CL	A–6	0
			42–80	Stratified loamy sand to sandy clay loam.	SM	A–2 or A–4	0
Grabe: Gr, Gs	B	>5	0–12	Sandy loam or loam	SM, ML	A–4, A–2	0
			12–30	Loam	ML	A–4	0
			30–60	Sandy loam	SM	A–2, A–4	0
Guest: Gt, Gu	D	>5	0–18	Clay loam or clay	CL, CH	A–6, A–7	0
			18–60	Clay	CH	A–7	0
Karro: Ka	B	>5	0–15	Loam	ML	A–4	0
			15–60	Clay loam	ML, MH	A–7, A–5	0
Kimbrough: KbE	D	½–1½	0–10	Gravelly loam and loam	GM, SM	A–2, A–4	0–5
			10–16	Lime-cemented hardpan			
Kimbrough variant: KhE.	D	½–1½	0–5	Very cobbly and gravelly loam.	GM	A–4, A–6	25–45
			5–8				
			8–12	Rhyolite.			
Luzena: LuD	D	½–1½	0–4	Gravelly clay loam	CL, GC	A–7	0–5
			4–13	Clay	CH	A–7	0
			13–60	Gneiss.			
Luzena variant: LvE	D	1–1½	0–3	Very cobbly loam	GM	A–2	40–60
			3–18	Cobbly clay loam and cobbly clay.	CL, CH	A–7	25–35
			18–27	Dacite.			
McAllister: Mc, Mk	C	>5	0–12	Loam	ML	A–4	0
			12–47	Clay loam	CL	A–6	0
			47–80	Fine sandy loam and loam	SM	A–4	0
Pima: Pm	B	>5	0–60	Stratified loam, clay loam, and silty clay loam.	CL, ML	A–6, A–4	0
Pridham: Pr[3]	D	>5	0–5	Loam	ML	A–4	0
			5–25	Clay	CH	A–7	0
			25–60	Clay loam	CL	A–6	0
Sonoita:							
SnA, SnB	B	>5	0–53	Sandy loam and gravelly sandy loam.	SM	A–2, A–1	0
			53–60	Very gravelly sand	SP, SP–SM	A–1	0–5
SoA	B	>5	0–53	Gravelly sandy loam	SM	A–1	0–5
			53–60	Very gravelly sand	SP, SP–SM	A–1	0–5
Stewart: St	D	½–1½	0–9	Light loam	ML	A–4	0
			9–22	Silica and lime-cemented hardpan.			
			22–60	Finely stratified loam to sand.	SM	A–4, A–2	0
Torrifluvents: To. Material too variable to rate.							
Torriorthents: TrC. Material too variable to rate.							

significant to engineering—Continued

Percentage less than 3 inches passing sieve—				Atterberg values		Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	Liquid limit	Plasticity index					Zinc-coated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
100	100	80–95	40–50	----------	NP	0.6–2.0	0.10–0.12	7.8–9.6	Low	High	Low.
100	100	90–100	65–80	20–30	10–15	<0.06	0.13–0.15	9.0–9.6	Moderate	High	High.
90–100	85–95	65–75	20–40	----------	NP	0.06–0.2	0.03–0.15	8.5–9.6	Low	High	High.
85–100	85–100	55–80	30–60	20–35	NP–5	2.0–6.0	0.13–0.15	6.6–8.4	Low	Moderate	Low.
85–100	85–100	85–95	60–75	30–40	NP–5	0.6–2.0	0.16–0.18	7.4–8.4	Low	Moderate	Low.
85–100	85–100	60–80	30–50	----------	NP	2.0–6.0	0.11–0.13	7.4–8.4	Low	High	Low.
100	100	95–100	70–90	35–55	15–30	0.2–0.6	0.19–0.21	7.4–8.4	Moderate or high.	High	Low.
100	100	95–100	75–95	65–80	45–55	0.06–0.2	0.14–0.16	7.9–8.4	High	High	Low.
100	95–100	85–95	50–60	30–40	NP–10	0.6–2.0	0.16–0.18	7.9–8.4	Low	High	Low.
85–100	85–100	80–95	60–80	40–55	5–25	0.2–0.6	0.11–0.13	8.4–9.6	Low	High	Moderate.
60–80	50–75	40–65	30–45	25–35	NP–10	0.6–2.0	0.12–0.14	7.4–8.4	Low	High	Low.
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60–70	55–65	45–60	35–50	35–50	5–15	0.6–2.0	0.08–0.09	7.4–8.4	Low	High	Low.
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65–75	60–75	60–70	45–60	40–50	15–25	0.2–0.6	0.10–0.12	6.1–7.8	Moderate	Moderate	Low.
65–90	60–90	55–90	50–80	50–60	20–30	0.06–0.2	0.14–0.16	6.6–7.8	High	Moderate	Low.
55–60	50–55	45–50	30–35	----------	NP	0.6–2.0	0.08–0.09	6.1–7.8	Low	Moderate	Low.
60–70	55–65	50–65	40–60	40–60	25–40	0.06–0.2	0.07–0.10	5.6–7.8	Moderate	Moderate	Low.
75–100	75–100	65–95	50–75	25–35	NP–10	0.6–2.0	0.13–0.18	7.9–9.6	Low	High	Low.
80–100	75–100	70–100	60–85	30–40	15–25	0.06–0.2	0.15–0.21	7.9–9.0	Moderate	High	Low.
100	95–100	70–85	20–30	35–40	NP–5	0.6–2.0	0.13–0.15	7.9–9.0	Low	High	Low.
100	100	95–100	75–90	30–40	5–20	0.2–0.6	0.16–0.21	7.4–8.4	Moderate	High	Low.
100	95–100	85–95	60–75	20–30	NP–5	0.6–2.0	0.16–0.18	6.6–9.0	Low	High	Moderate.
100	100	90–100	75–95	50–60	30–40	0.06–0.2	0.11–0.13	8.5–9.6	High	High	Low.
100	100	90–100	70–80	30–40	10–20	0.2–0.6	0.15–0.17	7.8–9.6	Moderate	High	Low.
85–90	70–80	40–50	20–35	----------	NP	2.0–6.0	0.09–0.11	5.6–8.4	Low	Moderate	Low.
65–70	30–40	15–25	0–10	----------	NP	6.0–20.0	0.03–0.05	7.9–8.4	Low	Moderate	Low.
75–85	50–70	30–40	15–25	----------	NP	2.0–6.0	0.07–0.09	5.6–8.4	Low	Moderate	Low.
65–70	30–40	15–25	0–10	----------	NP	6.0–20.0	0.03–0.05	7.9–8.4	Low	Moderate	Low.
100	100	85–95	60–70	30–40	0–10	0.6–2.0	0.13–0.15	8.5–9.6	Low	High	High.
----------	----------	----------	----------	----------	----------	<0.06	----------	----------	----------	----------	
90–100	85–100	80–90	30–45	15–30	NP–5	0.06–0.2	----------	8.5–9.6	Low	High	High.

TABLE 3.—*Estimated soil properties*

Soil series and map symbols	Hydrologic group	Depth to hardpan or bedrock	Depth from surface	USDA texture	Classification		Coarse fraction greater than 3 inches
					Unified	AASHO	
		Feet	*Inches*				*Percent*
Tubac:							
TuA	B	>5	0–16	Sandy loam	SM	A–2	0
			16–40	Clay and clay loam	CH	A–7	0
			40–60	Sandy loam and gravelly sandy loam.	SM	A–2	0
TvD	B	4	0–4	Gravelly loam	GM, SM	A–4, A–2	0
			4–47	Gravelly clay and clay	CH	A–7	0
			47–66	Strongly weathered rhyolite.			
TwA	B	>5	0–16	Sandy clay loam	SC	A–6	0
			16–40	Clay and clay loam	CH	A–7	0
			40–60	Sandy loam and gravelly sandy loam.	SM	A–2	0
Vinton: Vn	B	>5	0–66	Loamy fine sand and fine sand.	SM	A–2	0

[1] Nonplastic.
[2] Water table at a depth of 3 to 5 feet.
[3] Water table at a depth of 0 to 1½ feet.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill (trench type)[1]	Picnic areas	Playgrounds
Bernardino: BeC	Severe: slow permeability.	Slight where slopes are 0 to 2 percent. Moderate where slopes are 2 to 7 percent. Severe where slopes are more than 7 percent.	Severe: high shrink-swell potential.	Slight	Moderate: gravelly surface layer; slopes of more than 8 percent in places.	Severe: gravelly surface layer; slopes of more than 6 percent in places; slow permeability.
Cave: Ca	Severe: hardpan at a depth of 4 to 20 inches.	Severe: hardpan at a depth of 4 to 20 inches.	Severe: hardpan at a depth of 4 to 20 inches.	Severe: hardpan at a depth of 4 to 20 inches.	Moderate: gravel on surface.	Severe: hardpan at a depth of 4 to 20 inches; gravel on surface.
Cogswell: Cc, Cg	Severe: slow permeability.	Slight	Severe: high shrink-swell potential.	Moderate: clay loam texture.	Severe: dusty	Severe: dusty

significant to engineering—Continued

Percentage less than 3 inches passing sieve— No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	Atterberg values: Liquid limit	Atterberg values: Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity to—: Zinc-coated steel	Corrosivity to—: Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
100	85–90	60–70	25–35	--------	NP	2.0–6.0	0.11–0.13	5.5–7.3	Low------	Low------	Low.
100	85–100	80–95	70–85	60–75	40–50	0.06–0.2	0.14–0.21	6.6–8.4	High-----	High-----	Low.
75–90	70–85	40–60	25–35	25–35	NP–10	2.0–6.0	0.07–0.13	7.4–8.4	Low------	High-----	Low.
60–80	50–75	45–70	30–50	25–35	NP–10	0.6–2.0	0.13–0.15	6.1–7.3	Low------	Low------	Low.
75–95	70–90	65–75	55–65	60–75	40–50	0.06–0.2	0.11–0.16	6.1–7.8	High-----	High-----	Low.
100	90–100	70–90	35–50	40–50	15–30	0.2–0.6	0.14–0.16	5.5–7.3	Moderate-	Low------	Low.
100	85–100	80–95	70–85	70–80	50–60	0.06–0.2	0.16–0.18	6.6–8.4	High-----	High-----	Low.
75–90	70–85	40–60	25–35	25–35	NP–10	2.0–6.0	0.07–0.13	7.4–8.4	Low------	High-----	Low.
100	100	60–90	20–35	--------	NP	2.0–6.0	0.06–0.08	6.6–8.4	Low------	Moderate-	Low.

properties of the soils

Degree and kind of limitation for—Continued: Lawns and golf fairways	Local roads and streets	Suitability as source of—: Road fill	Sand and gravel	Topsoil	Soil features affecting—: Pond reservoir areas	Dikes, levees, and embankments	Irrigation
Severe: slow permeability; gravelly surface layer.	Severe: high shrink-swell potential.	Poor: CH material; high-shrink-swell potential.	Unsuited -----	Poor: clayey subsoil.	Slope in places; slow permeability.	Low shear strength; fair to poor compaction characteristics.	High available water capacity; slow permeability; slope in places.
Severe: hardpan at a depth of 4 to 20 inches; very low available water capacity.	Severe: hardpan at a depth of 4 to 20 inches.	Poor: hardpan at a depth of 4 to 20 inches.	Unsuited -----	Poor: hardpan at a depth of 4 to 20 inches; coarse fragments.	Hardpan at a depth of 4 to 20 inches.	Hardpan at a depth of 4 to 20 inches.	Very low available water capacity; hardpan at a depth of 4 to 20 inches.
Severe: slow permeability.	Severe: high shrink-swell potential.	Poor: CH material; high shrink-swell potential.	Unsuited [2] ----	Poor: clay-loam texture.	Slow permeability.	Low shear strength; fair to poor compaction characteristics.	High available water capacity; slow permeability.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill (trench type)[1]	Picnic areas	Playgrounds
Ce	Severe: slow permeability.	Slight	Severe: high shrink-swell potential.	Moderate: clay loam texture.	Severe: dusty	Severe: dusty
Comoro: CmA, CnA, CnC.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 10 percent. Flooding in some areas.	Severe: moderately rapid permeability; flooding in some areas.	Slight where slopes are less than 8 percent. Moderate where slopes are 8 to 10 percent. Flooding in some areas.	Severe: permeable soil material; flooding in some areas.	Slight	Slight
Comoro variant: Co	Severe: slow permeability.	Severe: slow permeability.	Moderate: moderate shrink-swell potential.	Severe: slow permeability.	Slight	Moderate: slow permeability.
Cowan: Cs	Slight	Severe: moderately rapid permeability.	Slight	Severe: moderately rapid permeability.	Slight	Slight
Crot: Ct	Severe: very slow permeability; seasonal high water table; flooding in some areas.	Severe: flooding in some areas; seasonal high water table.	Severe: seasonal high water table; flooding in some areas.	Severe: seasonal high water table; flooding in some areas.	Moderate: somewhat poorly drained; seasonal high water table.	Severe: very slow permeability; flooding in some areas; seasonal high water table.
Dry Lake: Dr	Severe: slow permeability.	Severe: 0 to 24 inches; rapid permeability.	Slight	Slight	Moderate: coarse-textured surface layer; restricted drainage.	Moderate: coarse-textured surface layer; restricted drainage; slow permeability.
Duncan: Du	Severe: hardpan at a depth of 20 to 40 inches.	Severe: hardpan at a depth of 20 to 40 inches.	Severe: high shrink-swell potential.	Severe: clayey texture; hardpan at a depth of 20 to 40 inches.	Moderate: dusty.	Severe: very slow permeability; dusty.

properties of the soils—Continued

Degree and kind of limitation for—Continued		Suitability as source of—			Soil features affecting—		
Lawns and golf fairways	Local roads and streets	Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and embankments	Irrigation
Severe: slow permeability: strongly saline-alkali.	Severe: high shrink-swell potential.	Poor: CH material; high shrink-swell potential.	Unsuited [2]	Poor: strongly saline-alkali; clayey.	Slow permeability.	Low shear strength; fair to poor compaction characteristics.	Strongly saline-alkali; moderate available water capacity; slow permeability.
Slight	Slight: flooding in some areas.	Good	Poor for sand: excessive fines. Unsuited for gravel.[2]	Fair: fine gravel.	Moderately rapid permeability; slopes of 5 to 10 percent in places.	Medium shear strength; medium susceptibility to piping.	Moderate to low available water capacity; moderately rapid permeability; slope in places; hazard of flooding.
Severe: slow permeability.	Moderate: low strength.	Good	Good for sand. Poor for gravel after sieving.	Fair: thin layer.	Rapid permeability below a depth of 49 inches.	Medium shear strength; medium susceptibility to piping; fair compaction characteristics.	Moderate available water capacity; slow permeability; strongly saline-alkali below a depth of 24 inches.
Moderate: moderate available water capacity.	Slight	Good	Poor for sand, more than 20 percent fines. Unsuited for gravel.	Good	Moderately rapid permeability.	Medium shear strength; high susceptibility to piping.	Moderate available water capacity; moderately rapid permeability.
Severe: very slow permeability; strongly to very strongly saline-alkali.	Moderate: low strength; flooding in some areas; moderate shrink-swell potential.	Fair: SC material with more than 30 percent fines; somewhat poorly drained.	Poor: excessive fines.[2]	Poor: strongly to very strongly saline-alkali.	Very slow permeability; seasonal high water table.	Medium shear strength; medium susceptibility to piping; fair compaction characteristics; seasonal high water table.	Moderate available water capacity; very slow permeability; strongly to very strongly saline-alkali; seasonal high water table.
Moderate: loamy sand surface layer.	Slight	Fair: low strength.	Unsuited	Poor: loamy sand texture above a depth of 24 inches; strongly saline-alkali below.	Rapid permeability above a depth of 24 inches; slow permeability below.	SM material above a depth of 24 inches; medium to high susceptibility to piping. Low shear strength below a depth of 24 inches; fair compaction characteristics; medium susceptibility to piping.	Moderate available water capacity; rapid permeability above a depth of 24 inches, slow permeability below; strongly to very strongly saline-alkali below a depth of 24 inches.
Severe: very slow permeability; strongly saline-alkali.	Severe: high shrink-swell potential; hardpan at a depth of 20 to 40 inches.	Poor: CH and CL material; hardpan at a depth of 20 to 40 inches.	Unsuited [2]	Poor: strongly saline-alkali.	Very slow permeability; hardpan at a depth of 20 to 40 inches.	Low shear strength; fair compaction characteristics; hardpan at a depth of 20 to 40 inches.	Low available water capacity; strongly to very strongly saline-alkali; hardpan at a depth of 20 to 40 inches.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill (trench type)[1]	Picnic areas	Playgrounds
Duncan variant: Dv	Severe: somewhat poorly drained; hardpan at a depth of 4 to 20 inches.	Severe: hardpan at a depth of 4 to 20 inches; somewhat poorly drained.	Severe: hardpan at a depth of 4 to 20 inches; high shrink-swell potential above hardpan.	Severe: hardpan at a depth of 4 to 20 inches; somewhat poorly drained.	Moderate: dusty; somewhat poorly drained.	Severe: very slow permeability; dusty.
Elfrida: Ef	Severe: moderately slow permeability.	Slight	Moderate: moderate shrink-swell potential.	Moderate: clay loam texture.	Moderate: dusty.	Moderate: moderately slow permeability; dusty.
Forrest: FoA, FrA, FrB.	Severe: slow permeability.	Slight where slopes are 0 to 2 percent. Moderate where slopes are 2 to 5 percent.	Severe: high shrink-swell potential.	Moderate: clay loam texture.	Slight	Moderate: slow permeability.
Frye: Fy	Severe: hardpan at a depth of 18 to 30 inches.	Severe: hardpan at a depth of 18 to 30 inches.	Severe: high shrink-swell potential.	Severe: clay texture; hardpan at a depth of 18 to 30 inches.	Slight	Moderate: slow permeability.
Gothard: Go	Severe: very slow permeability.	Slight	Moderate: moderate shrink-swell potential.	Moderate: clay loam texture.	Moderate: dusty.	Severe: very slow permeability.
Grabe: Gr, Gs	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Slight	Slight	Slight
Guest: Gt, Gu	Severe: slow permeability.	Slight	Severe: high shrink-swell potential.	Severe: clayey texture below a depth of 18 inches.	Moderate where surface layer is clay loam: dusty. Severe where surface layer is clay.	Moderate where surface layer is clay loam: dusty; slow permeability. Severe where surface is clay.

properties of the soils—Continued

Degree and kind of limitation for—Continued		Suitability as source of—			Soil features affecting—		
Lawns and golf fairways	Local roads and streets	Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and embankments	Irrigation
Severe: hardpan at a depth of 4 to 20 inches; strongly to very strongly saline-alkali.	Severe: flooding in some areas; hardpan at a depth of 4 to 20 inches.	Poor: hardpan at a depth of 4 to 20 inches.	Unsuited	Poor: strongly saline-alkali; hardpan at a depth of 4 to 20 inches.	Very slow permeability; hardpan at a depth of 4 to 20 inches.	Medium shear strength; low susceptibility to piping; fair compaction characteristics; hardpan at a depth of 4 to 20 inches.	Very low available water capacity; strongly to very strongly saline-alkali; hardpan at a depth of 4 to 20 inches.
Moderate: moderately slow-permeability.	Severe: CL material.	Poor: CL material.	Unsuited	Fair: silty clay loam texture.	Moderately slow permeability.	Medium shear strength; low compacted permeability; fair compaction characteristics.	High available water capacity; moderately slow permeability.
Severe: slow permeability.	Severe: high shrink-swell potential; CH material.	Poor: CL and CH material; high shrink-swell potential.	Unsuited	Poor: limited thickness of loam material.	Moderately slow and moderate permeability below a depth of 29 inches.	Medium to low shear strength; fair compaction characteristics.	High available water capacity; slow permeability; slope in some areas.
Severe: slow permeability; hardpan at a depth of 18 to 30 inches.	Severe: high shrink-swell potential; hardpan at a depth of 18 to 30 inches.	Poor: CH material; hardpan at a depth of 18 to 30 inches.	Unsuited	Fair: limited thickness of sandy loam and loam material.	Slow permeability; hardpan at a depth of 18 to 30 inches.	Medium to low shear strength; fair compaction characteristics; hardpan at a depth of 18 to 30 inches.	Low available water capacity; slow permeability; hardpan at a depth of 18 to 30 inches.
Severe: very slow permeability.	Moderate: moderate shrink-swell potential.	Moderate: CL material; moderate shrink-swell potential.	Unsuited	Poor: strongly alkali.	Very slow permeability.	Medium to low shear strength; fair compaction characteristics.	High available water capacity; very slow permeability; strongly to very strongly alkali.
Slight	Moderate: low strength.	Fair: low strength.	Unsuited	Good	Moderate permeability.	Medium to low shear strength; fair to good compaction characteristics; medium to high susceptibility to piping.	High available water capacity; moderate permeability.
Severe: slow permeability.	Severe: high shrink-swell potential; CH material.	Poor: CH material; high shrink-swell potential.	Unsuited	Poor: clayey texture below a depth of about 18 inches.	Slow permeability.	Medium to low shear strength; fair to poor compaction characteristics.	High available water capacity; slow permeability.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill (trench type)[1]	Picnic areas	Playgrounds
Karro: Ka	Severe: moderately slow permeability.	Slight	Moderate: MH material; low strength.	Moderate: clay loam texture.	Moderate: dusty.	Moderate: moderately slow permeability; dusty.
Kimbrough: KbE	Severe: hardpan above a depth of 20 inches; moderately steep slopes.	Severe: hardpan above a depth of 20 inches; moderately steep slopes.	Severe: hardpan above a depth of 20 inches; moderately steep slopes.	Severe: hardpan above a depth of 20 inches.	Moderate where slopes are 0 to 15 percent: gravel. Severe where slopes are more than 15 percent.	Severe: hardpan above a depth of 20 inches; slopes generally more than 6 percent.
Kimbrough variant: KhE.	Severe: bedrock above a depth of 20 inches; slope.	Severe: bedrock above a depth of 20 inches; slope.	Severe: bedrock above a depth of 20 inches; slope.	Severe: bedrock above a depth of 20 inches; slope.	Severe: slope	Severe: slope; more than 20 percent coarse fragments on surface.
Luzena: LuD	Severe: bedrock above a depth of 20 inches.	Severe: bedrock above a depth of 20 inches; slope.	Severe: high shrink-swell potential; bedrock above a depth of 20 inches.	Severe: bedrock above a depth of 20 inches.	Moderate: slow permeability; coarse fragments on surface; slope.	Severe: bedrock above a depth of 20 inches; coarse fragments on surface; slope.
Luzena variant: LvE.	Severe: bedrock above a depth of 20 inches; slope.	Severe: bedrock above a depth of 20 inches; slope.	Severe: bedrock above a depth of 20 inches; slope.	Severe: bedrock above a depth of 20 inches.	Severe: slope; cobbly surface layer.	Severe: slope; bedrock above a depth of 20 inches; coarse fragments on surface.
McAllister: Mc, Mk	Severe: moderately slow permeability.	Slight	Moderate: moderate shrink-swell potential.	Moderate: clay loam texture.	Moderate: dusty.	Moderate: dusty; moderately slow permeability.
Pima: Pm	Severe: moderately slow permeability.	Slight	Moderate: moderate shrink-swell potential.	Moderate: clay loam texture.	Moderate: dusty.	Moderate: dusty; moderately slow permeability.

properties of the soils—Continued

Degree and kind of limitation for—Continued		Suitability as source of—			Soil features affecting—		
Lawns and golf fairways	Local roads and streets	Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and embankments	Irrigation
Moderate: moderately slow permeability.	Severe: MH material; low strength.	Poor: ML and MH materials; low strength.	Unsuited	Fair: thin layer of loam.	Moderately slow permeability.	Medium to low shear strength; low to medium susceptibility to piping; fair to poor compaction characteristics.	High available water capacity; moderately slow permeability.
Severe: hardpan above a depth of 20 inches.	Severe: moderately steep slopes; hardpan above a depth of 20 inches.	Poor: hardpan above a depth of 20 inches.	Unsuited	Poor: hardpan above a depth of 20 inches; coarse fragments.	Hardpan above a depth of 20 inches; moderately steep slopes.	Medium susceptibility to piping; hardpan above a depth of 20 inches.	Unsuited: moderately steep slopes; hardpan above a depth of 20 inches.
Severe: bedrock above a depth of 20 inches; slope.	Severe: slope; bedrock above a depth of 20 inches.	Poor: bedrock above a depth of 20 inches.	Unsuited	Poor: bedrock above a depth of 20 inches; excessive coarse fragments.	Bedrock above a depth of 20 inches; slope.	Medium susceptibility to piping; bedrock above a depth of 20 inches.	Cobblestones and bedrock above a depth of 20 inches; slope.
Severe: bedrock above a depth of 20 inches; slow permeability; coarse fragments on surface.	Severe: bedrock above a depth of 20 inches.	Poor: bedrock above a depth of 20 inches.	Unsuited	Poor: bedrock above a depth of 20 inches; coarse fragments.	Slow permeability; slope; bedrock above a depth of 20 inches.	Medium to low shear strength; fair to poor compaction characteristics; bedrock above a depth of 20 inches.	Bedrock above a depth of 20 inches; slope.
Severe: bedrock above a depth of 20 inches; slope.	Severe: slope; bedrock above a depth of 20 inches; highly plastic material.	Poor: bedrock above a depth of 20 inches; CL and CH materials.	Unsuited	Poor: bedrock above a depth of 20 inches; excessive coarse fragments.	Slow permeability; bedrock above a depth of 20 inches.	Medium to low shear strength; fair to poor compaction characteristics; bedrock above a depth of 20 inches.	Unsuited: slope; very low available water capacity; cobbly; bedrock above a depth of 20 inches.
Moderate for Mc: moderately slow permeability. Poor for Mk: strongly saline-alkali.	Moderate: low strength; moderate shrink-swell potential.	Poor: CL material; moderate shrink-swell potential.	Unsuited	Fair for Mc: thin layer; gravel. Poor for Mk: strongly saline-alkali.	Slow permeability.	Medium to low shear strength; fair to poor compaction characteristics; medium susceptibility to piping.	High available water capacity; slow permeability; Mk is strongly saline-alkali in spots.
Moderate: moderately slow permeability.	Moderate: CL and ML materials; moderate shrink-swell potential.	Fair: CL material.	Unsuited	Fair: clay loam and silty clay loam texture.	Moderately slow permeability.	Medium to low shear strength; fair to good compaction characteristics; medium susceptibility to piping.	High available water capacity; moderate permeability.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill (trench type)[1]	Picnic areas	Playgrounds
Pridham: Pr	Severe: slow permeability; high water table.	Severe: high water table.	Severe: high shrink-swell potential; high water table.	Severe: clayey texture; high water table.	Moderate: high water table.	Severe: high water table.
Sonoita: SnA, SnB, SoA.	Slight	Severe: moderately rapid permeability.	Slight	Severe: moderately rapid permeability.	Slight for SnA and SnB. Moderate for SoA: gravel.	Slight for SnA and SnB. Severe for SoA: gravel.
Stewart: St	Severe: very slow permeability; somewhat poorly drained.	Severe: hardpan above a depth of 20 inches; somewhat poorly drained.	Severe: hardpan above a depth of 20 inches.	Severe: hardpan above a depth of 20 inches; somewhat poorly drained.	Moderate: dusty; somewhat poorly drained.	Severe: very slow permeability; dusty.
Torrifluvents: To	Severe: hazard of flooding.	Severe: hazard of flooding.	Severe: hazard of flooding.	Severe: hazard of flooding.	Moderate: hazard of flooding.	Severe: hazard of flooding.
Torriorthents, hummocky: TrC. Material too variable to rate.						
Tubac: TuA, TwA	Severe: slow permeability.	Slight	Severe: high shrink-swell potential.	Severe: clayey texture.	Slight for TuA. Moderate for TwA: sandy clay loam surface layer.	Moderate: slow permeability.
TvD	Severe: slow permeability; slope; bedrock at a depth of 48 inches.	Severe: slope.	Severe: high shrink-swell potential.	Severe: bedrock at a depth of 48 inches.	Moderate where slopes are 10 to 15 percent: gravelly. Severe where slopes are 15 to 20 percent.	Severe: slow permeability; slope.
Vinton: Vn	Slight	Severe: moderately rapid permeability.	Slight	Severe: coarse-textured materials; moderately rapid permeability.	Moderate: loamy sand surface layer.	Moderate: loamy sand surface layer.

[1] Onsite study is needed of the deep underlying strata, the water table, and the hazards of aquifer pollution and drainage into ground water in landfill deeper than 5 or 6 feet.

properties of the soils—Continued

Degree and kind of limitation for—Continued		Suitability as source of—			Soil features affecting—		
Lawns and golf fairways	Local roads and streets	Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and embankments	Irrigation
Severe: slow permeability; high water table; strongly saline-alkali.	Severe: high shrink-swell potential; CH material.	Poor: CH material; high shrink-swell potential; high water table.	Unsuited	Poor: strongly saline-alkali; clayey texture.	Slow permeability; high water table.	Medium to low shear strength; fair to poor compaction characteristics.	High available water capacity; slow permeability; high water table; strongly saline-alkali.
Slight	Slight	Good	Good for sand. Poor for gravel after sieving.	Good for SnA and SnB. Poor for SoA: gravel.	Moderately rapid permeability.	Medium susceptibility to piping.	Moderate or low available water capacity; moderately rapid permeability; slope in places.
Severe: hardpan above a depth of 20 inches; very strongly saline-alkali.	Severe: hardpan above a depth of 20 inches.	Poor: hardpan above a depth of 20 inches.	Unsuited	Poor: strongly saline-alkali; hardpan above a depth of 20 inches.	Very slow permeability; hardpan above a depth of 20 inches.	High susceptibility to piping; hardpan above a depth of 20 inches.	Hardpan above a depth of 20 inches; very low available water capacity; very strongly alkaline.
Severe: hazard of flooding.	Severe: hazard of flooding.	Material too variable to rate.	Material too variable to rate.	Material too variable to rate.	Material too variable to rate.	Material too variable to rate.	Hazard of flooding; very low available water capacity; rapid permeability.
Severe: slow permeability.	Severe: high shrink-swell potential.	Poor: CH material; high shrink-swell potential.	Unsuited	Fair: thin layer; clayey texture; gravel at a depth of 12 inches.	Slow permeability above a depth of about 40 inches; moderately rapid permeability below.	Medium shear strength; fair compaction characteristics.	High available water capacity; slow permeability.
Severe: slow permeability; slope.	Severe: slope; high shrink-swell potential.	Poor: CH material; high shrink-swell potential.	Unsuited	Poor: coarse fragments; slope.	Slow permeability; slope.	Medium shear strength; fair compaction characteristics.	High available water capacity; slow permeability; slope.
Moderate: loamy sand surface layer; low available water capacity.	Slight	Good	Poor for sand: excessive fines. Unsuited for gravel.	Poor: loamy sand surface layer.	Moderately rapid permeability.	High susceptibility to piping; medium shear strength.	Low available water capacity; moderately rapid permeability; slope in places.

[3] Around the Willcox Playa the soil substratum is quite variable and highly stratified. Suitability may vary from poor to good within short distances. Onsite investigation is needed.

TABLE 5.—*Engineering*

[Tests performed by the Arizona Highway Department in cooperation with the U.S. Department of Commerce, Bureau of Public

Soil series and location	Report number S64 Ariz–2–	Depth	Classification			Moisture density [1]	
			USDA [3]	AASHO [4]	Unified [5]	Maximum dry density	Optimum moisture content
		In				*Lb/ft³*	*Pct*
Gothard:							
2,640 feet W. and 2,540 feet S. of NE corner of sec. 27, T. 16 S., R. 25 E.	20	5–11	Clay loam	A–7–6 (17)	CL	96	20
		11–24	Loam	A–6 (13)	CL	101	19
		24–42	Clay loam	A–6 (9)	CL	114	15
		51–80	Sandy loam	A–2–4 (0)	SM–SC	109	17
1,050 feet E. and 350 feet N. of S. quarter corner of sec. 21, T. 16 S., R. 25 E.	21	2–7	Clay	A–7–6 (17)	CL	97	21
		7–20	Sandy clay loam	A–6 (11)	CL	112	14
		20–40	Sandy clay loam	A–6 (6)	CL	114	14
		51–58	Sandy loam	A–6 (2)	SC	110	14
Karro:							
1,075 feet N. and 600 feet E. of S. quarter corner of sec. 11, T. 16 S., R. 24 E.	23	0–12	Loam	A–4 (4)	ML	95	24
		20–27	Clay loam	A–7–5 (20)	CH	90	28
		27–42	Clay loam	A–7–6 (17)	CH	93	26
2,000 feet N. and 330 feet W. of SE. corner of sec. 12, T. 16 S., R. 25 E.	24	0–22	Loam	A–4 (4)	ML	95	23
		22–32	Clay loam	A–7–5 (19)	MH–CH	93	24
		32–42	Clay loam	A–7–6 (13)	CL	96	23
Tubac:							
800 feet S. and 50 feet W. of NE. corner of sec. 24, T. 12 S., R. 24 E.	29	11–19	Clay	A–7–6 (19)	CH	98	21
		39–57	Sandy loam	A–4 (1)	SC	115	12

[1] Based on AASHO Designation T 99, Method A (*1*).

[2] Mechanical analyses according to AASHO Designation T 88–57 (*1*). Results by this procedure frequently may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and

and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or of material having this rating.

Corrosivity, as used in table 3, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete (fig. 13). Rate of corrosion of uncoated steel is related to soil properties such as drainage, texture, total acidity, and electrical conductivity of the soil material. Corrosivity for concrete is influenced mainly by the content of sodium, water-soluble calcium, or magnesium sulfate, but also by soil texture and acidity. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. A corrosivity rating of *low* means that there is a low probability of soil-induced corrosion damage. A rating of *high* means that there is a high probability of damage, so that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

Engineering interpretations of the soils

The estimated interpretations in table 4 are based on the engineering properties of soils shown in table 3, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of the Willcox Area. In table 4, ratings are used to summarize the limitation or suitability of the soils for all listed purposes other than for irrigation, ponds and reservoirs, and embankments. For these particular uses, table 4 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings slight, moderate, and severe. *Slight* means that soil properties are generally favorable for the rated use; in other words, the limitations are minor and are easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means that soil properties are so unfavorable and so difficult to correct or overcome as to require major soil reclamation, special designs, or intensive maintenance.

Soil suitability is rated by the terms *good, fair,* and *poor*, which have respectively, meanings approximately parallel to the terms slight, moderate, and severe.

test data

Roads, in accordance with standard procedures of the American Association of State Highway Officials (AASHO) (*1*)]

Mechanical analysis [2]									Liquid limit	Plasticity index
Percentage passing sieve—						Percentage smaller than—				
3/4 in.	3/8 in.	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.02 mm	0.005 mm	0.002 mm		
----------	----------	100	100	97	71	44	28	11	48	33
----------	----------	----------	100	96	74	31	18	8	39	23
----------	----------	----------	100	96	65	20	12	5	32	18
100	98	94	88	69	26	14	9	3	34	10
----------	----------	----------	100	98	78	48	31	10	46	29
----------	----------	100	99	94	60	44	34	23	36	24
----------	----------	100	98	89	52	36	28	19	28	16
----------	----------	100	98	75	36	20	13	5	38	17
----------	----------	100	96	83	54	28	18	8	34	9
----------	----------	100	100	95	79	21	13	9	65	34
----------	----------	----------	100	94	72	26	16	10	53	28
----------	100	98	98	82	54	22	13	4	34	8
----------	----------	----------	100	98	92	18	11	9	58	28
----------	----------	100	99	96	85	36	24	14	45	23
100	99	97	93	82	69	63	56	48	70	51
[6] 97	94	89	82	66	38	19	10	3	28	10

the material coarser than 2 millimeters in diameter is excluded from the calculations of the grain-size fractions. The mechanical analyses data used in this table are not suitable for use in naming textural classes of soil.

[3] By field determination.

[4] Based on AASHO Designation M 145–49 (*1*).

[5] Based on the Unified soil classification system (*14*).

[6] 100 percent passes the 2-inch sieve.

Following are explanations of some of the columns in table 4.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material between depths of 18 inches and 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects difficulty of layout and construction and also the risk of erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumptions are made that the embankment is compacted to medium density and that the embankment protects the pond from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic-matter content, and slope, and if the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified soil classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Dwellings without basements, as rated in table 4, are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular

Figure 13.—**Corrosion damage to buried metal gaslines after only 3 years in Crot sandy loam.**

traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated the ratings in table 4 apply only to a depth of about 6 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 to 15 feet, but regardless of that, every site should be investigated before it is selected.

Picnic areas are attractive natural or landscaped tracts used primarily for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry; are free of flooding during the season of use; and do not have slopes or stoniness that greatly increases cost of leveling sites or of building access roads.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops, good drainage, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry. If grading and leveling are required, depth to rock is important.

Lawns and golf fairways are tracts around residences, factories, apartment houses, and school buildings and in intensively used parks and golf courses. These ratings are based on soil properties such as slope, texture of the surface layer, soil depth, permeability, available water capacity, drainage, and salt and alkali content. The ratings do not take into account other factors, such as location, that are important in selecting a site. They do not refer to golf greens and sand traps, because most of these are manmade. The need for leveling or for topsoil, or the kind of grass on the areas, was not considered in the ratings.

Local roads and streets, as rated in table 4, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly of asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Road fill is soil material used in embankments for roads. The suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and (2) the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 4 provide guidance about where to look for profitable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is above a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, nor do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that will result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Dikes, levees, and embankments require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and com-

pactibility. Presence of stones or organic material in a soil is unfavorable.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans, or other layers that restrict movement of water; amount of water held available to plants; and need for drainage, or depth to water table or bedrock.

Test data

Table 5 contains engineering test data for some of the major soil series in the Willcox Area. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limit and plastic limit. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the optimum moisture content is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed maximum dry density. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Formation, Morphology, and Classification of the Soils

This section discusses the factors of soil formation and relates them to the soils in the Willcox Area, describes the morphology of the soils, and places the soils in some categories of the classification system. It also gives laboratory analysis data on selected soils in the Area.

Factors of Soil Formation

The Willcox basin is the only large closed basin in the Basin and Range Province of Southern Arizona. The soils near the center of the basin formed in lacustrine material from Pleistocene Lake Cochise and associated alluvial deposits. The surrounding soils on stable alluvial fans formed in part during the Wisconsin pluvial period, but they may be much older.

Soils in the Willcox Area are influenced during their formation by five factors: parent material, climate, plant and animal life, relief, and time. Of these five factors, climate may have been dominant because of its changes during the Pleistocene and recent times.

Parent material

The mountain ranges surrounding the Willcox basin consist of many kinds of crystalline rock, such as basalt, andesite, rhyolite, volcanic tuff, and limestone. During the Pleistocene, the basin contained at least one pluvial lake, Lake Cochise. Although no detailed work on the history of this lake has been published, extensive beaches have been recognized 50 feet above the playa, and fragments of beaches are at the 60 foot level. Older lake levels may have been slightly higher, but the boundary between soils of contrasting morphology is now about 60 feet above the playa floor.

Climate

Climate has a strong influence on soil formation. Heat and moisture greatly influence the kind of vegetation that grows and the rate at which organic matter decomposes and minerals weather. Heat and moisture also influence the rate of removal of material from some soil horizons and the rate of accumulation in others.

In the Willcox Area the summers are hot and moist, and more than half of the annual precipitation falls in July, August, and September. The winters are cool and slightly moist. By late spring the soils are normally dry because of the lack of rain and the drying effect of the wind. Plant growth, mostly of grasses and shrubs, is practically at a standstill in spring but is quite rapid with the coming of rain in June and July. Brush and tree growth begins in midspring because the roots are able to store moisture and to tap sources of moisture below the reach of grass roots.

The oxidation of organic matter during the hot summer and the limited growth period permit little accumulation of organic matter. As a result, all of the soils except those in swales, on flood plains, and on low terraces are low in organic matter as compared with the soils on the upper part of foothills, where the climate is slightly more humid.

The amount of precipitation increases gradually with elevation from about 9 inches at the south end of the Willcox Playa to about 15 inches at the lower edge of the foothills. Most of the survey area receives 10 to 12 inches of rain. Such a limited range does not account for important soil differences. Likewise, temperature variations are not sufficient to account for appreciable differences between soils. The average annual temperature is about 60° to 62° F.

The younger soils that are forming under the semiarid climate of the valley have a surface layer that is light colored, massive to weak in structure, and moderately alkaline to very strongly alkaline. The subsoil is moderately alkaline to very strongly alkaline. The older soils on the high terraces or valley plains are less alkaline in reaction and have well-developed profiles. These facts agree with the detailed palynographic work of Martin (*5*) in the Willcox Playa. Martin found several pluvial pollen zones in core samples of the playa. One of these was similar to that of the yellow pine parkland in the Chuska Mountains of northern New Mexico at an elevation of 8,450 feet. Another had higher concentrations of pine pollen than any yet found in a modern natural environment. The Chuska Mountains have about 31 inches of precipitation, and the climate of the Willcox basin during the Wisconsin pluvial period may have been similar.

Plant and animal life

The Willcox Playa lacks vegetation. The surrounding highly alkaline and saline soils have a plant cover of salt-tolerant grasses, alkali lovegrass, inland saltgrass,

alkali sacaton, and saltbush. On the neutral to moderately alkaline soils on the bajadas above the playa are desert grasses and some desert shrubs, on the foothills are chaparral and oak, and on the higher mountains around the basin are some yellow pine forests.

On the more favorable sites of flood plains, in broad swales, and on low terraces, a lush growth of vegetation provides the organic matter that gives the Cogswell, Comoro, Elfrida, Grabe, Guest, Pima, and Pridham soils their dark color. On the valley plains the plant cover changes to desert grasses and scattered shrubs. Though the rainfall in each area is about the same, the valley plains lose some moisture through runoff to the lower lying areas. Such soils as Sonoita soils, which occupy valley plains, have a lighter colored surface layer than soils in the lower lying areas. The chaparral and oak in the foothills and the yellow pine forests in the mountains provide organic matter to soils such as Luzena soils, which have a dark-colored surface layer.

Small animals, earthworms, insects, and micro-organisms also influence the formation of soils. They mix organic matter into the soil and help to break down the remains of plants. Small animals, such as rodents, burrow into the soil and mix the layers. Krotovinas caused by the filling of tunnels made by burrowing animals are common in the Frye, Dry Lake, and Karro soils. Earthworms and other small invertebrates feed on the organic matter in the upper few inches, especially in the darker colored soils. Bacteria, fungi, algae, actinomyces, and other micro-organisms hasten the weathering of rocks and the decomposition of plant remains.

Relief

Relief, through its effect on drainage, erosion, and sedimentation, has influenced soil formation in the Willcox Area. In the lower part of the basin, the soils are finer textured and have a higher water table. Most of the precipitation collects on the surface of these soils, which causes reduction of iron and manganese and the accumulation of salts, particularly sodium, in parts of the profile. Moderately well drained or somewhat poorly drained soils such as Crot, Duncan, shallow variant, Gothard, Dry Lake, Pridham, and Stewart soils are in these low areas. These soils have a dense cover of alkali sacaton and inland saltgrass. Of these soils, only Duncan, shallow variant, and Stewart soils have a duripan or a silica- and lime-cemented hardpan.

In the slightly higher areas, the soils have better natural drainage and are free of salts and alkali, but calcium carbonate accumulates. Cogswell, Elfrida, and Karro soils have calcic horizons; that is, horizons of carbonate accumulation. In none of these soils has the accumulation of calcium carbonate been sufficient to cause induration.

Time

Soils form more slowly in the arid desert than in areas where rainfall is more plentiful, because there is less water for weathering, for leaching of weathered products, and for translocation of clay. Consequently, under the present climatic regime soil properties change slowly with time. The marked variations in the formation of such soils as Vinton and Tubac would require extremely great differences in age if the variations were a result of time alone. However, the variations in such soils seem best explained by a combination of differences in time and in climatic regimes. For example, the older Tubac soil formed during one or more pluvial periods of the Wisconsin and Illinoian times, whereas the Vinton soil formed under the present, drier climatic regime.

Morphology of the Soils

Lake Cochise existed in the Willcox Area during the late Pleistocene Epoch. Its shoreline was about 50 feet above the edge of Willcox Playa. The beach deposits of this lake and the alluvial fans, stream deposits, and erosional surfaces upslope mark the boundary between soils that formed during the pluvial periods of Pleistocene time and soils that formed afterward. The cooler, wetter climate that produced Lake Cochise is the single most important factor in the formation of the older soils of the Area. Those soils that existed during the Pleistocene have many features dating from that time.

Willcox Playa, which floods in wet years, is barren of vegetation. Sediment in the playa is clay and a small amount of silt. A large part of the silt is carbonate. The clay has mixed mineralogy; clay mica is the major component, but small amounts of smectite and kaolinite are present. Natural drainage of the playa is poor or very poor. Salts accumulate; sodium chloride is most common, but considerable amounts of sodium sulfate are also present. Some zeolites are in the fine sediment of the playa. The high level of sodium and potassium salts and soluble silica maintains an alkaline environment that favors formation of zeolites.

Surrounding the Willcox Playa are some soils that have formed since Lake Cochise receded, and therefore, they must have formed under a climate similar to the present one. Some of these soils, such as Gothard, Duncan, and Crot soils, formed in fine-textured alluvium and lake sediment and have well-developed profiles. Others, such as Dry Lake and Karro soils, formed on beach ridges and dunes and are higher in carbonates, are coarser textured, and have profiles that are less developed.

Gothard soils (see tables 7 and 8) formed in lake sediment. They have a natric horizon and a calcic horizon in which carbonate accumulates in the clay as well as in the coarser particles. The irregular decrease in clay content with increasing depth is not thought to be a result of discontinuity. Instead, it is a consequence of the distribution of carbonate clay and silicate clay, because the maximum concentration of the two kinds of clay occur at different depths. Gothard soils also have accumulations of salt, mostly sodium sulfate.

Dry Lake soils formed in sandy, highly calcareous material on wind-worked beach ridges and deltaic deposits. Dry Lake soils are thought to be as old as Gothard soils but are coarser textured and in a dryer position. The profile of Dry Lake soils (see tables 7 and 8) has a calcic horizon but has neither a natric horizon nor a duripan. It has accumulated some salt in the lower part of the profile, mostly sodium sulfate. The sulfate accumulation in the Dry Lake, Gothard, Duncan, Crot, and surrounding soils may reflect poor drain-

age that existed in the Area during and immediately following the Pleistocene.

Immediately above the deposits of Lake Cochise are some deep, well-drained, moderately alkaline soils that have a calcic horizon at a shallow to moderate depth. These soils are on the lower end of the fans of larger streams that entered Lake Cochise. Karro soils (see table 8) have more carbonate clay than silicate clay. The carbonate clay is more like silt in its physical and chemical properties. Karro soils accumulate very little salt, most of which is chloride and bicarbonate.

Frye, Forrest, and similar soils formed in the sandy and loamy sediment above Lake Cochise. These soils are on low fans that had restricted drainage during the time of Lake Cochise. Frye soils (see tables 7 and 8) have a fine-textured, reddish-brown, argillic horizon that is underlain by a duripan that has a laminar cap. Some salt, mostly chloride, has accumulated in the argillic horizon just above the duripan, in the duripan itself, and in the underlying horizons. The soils are moderately alkaline. They are slowly permeable to air and water, and root growth is restricted by the duripan.

Soils such as Tubac soils are deep and well drained, and they have a strongly developed, reddish-brown and red B horizon. They are slightly acid to neutral. They are on stable fans above the level of Lake Cochise and formed mainly during Illinoian and Wisconsin times. Many of their properties apparently developed during the cooler, wetter pluvials of the Pleistocene. Tubac soils (see tables 7 and 8), the most strongly developed soils, are Paleargids that have an increase of more than 15 percent in clay content from the A3 horizon to the B21t horizon, and they have more than 35 percent clay in the upper 20 inches of the argillic horizon. They also have a little salt in the lower part of the profile, mostly chlorides. The clay consists of a mixture of montmorillonite, mica, and kaolinite. These soils are slowly permeable to air and water because of their fine texture, but there are no restricting layers.

Kimbrough and Cave soils are very shallow and shallow, are well drained, and have a lime-cemented hardpan. They are old soils or contain remnants of old soils. They are on pediments along mountain foot slopes or are around mountain peaks of andesite, rhyolite, or granite. Some of the characteristics of these soils may be seen in the data for Kimbrough soils (tables 7 and 8). The profile has a dark-colored surface layer that has granular structure and supports a fair cover of black and side-oats grama, wolftail, tall three-awn, and other grasses. Immediately underlying the surface layer is a massive lime-cemented hardpan that has a half-inch laminar cap. The soil is moderately alkaline and has a marked accumulation of carbonate in the hardpan. The hardpan restricts the movement of water and the growth of roots, but there is very little buildup of salt above it. The clay consists largely of montmorillonite and carbonate.

Luzena and similar soils are on the hilly to extremely steep mountain slopes at the edge of the Willcox basin. These soils include very shallow, shallow, and deep, dark-colored soils that formed in residuum from granite, schist, quartzite, volcanic rocks, and limestone. Some of the soils, mostly those on hills, are old soils or contain parts of old soils. They are sufficiently developed to have argillic horizons; that is, horizons of clay accumulation. The steeper soils lack a horizon of clay accumulation, but most have a dark-colored surface layer. Most of the soils that formed in residuum from granite and schist are deeper than those that formed in residuum from volcanic rock and limestone. Smectite minerals are dominant in the soils that formed over granite, schist, and basic volcanic rocks, whereas soils that formed over acid volcanic rocks and limestone have a mixture of clay minerals.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about soils, to see the relationships of one to another and to the whole environment, and to develop principles that help us understand the behavior and response of soils to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and used in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system currently used in the United States was adopted for general use by the National Cooperative Soil Survey in 1965 *(12)*. The current system is under continual study. Therefore, readers interested in developments of the current system should search the latest literature available *(4, 7, 8)*. In table 6, the soil series in the Willcox Area are placed in some categories of the current system.

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis or mode of origin are grouped together. Most of the classes of the current system are explained briefly in the following paragraphs.

ORDER: Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Ent–i–sol).

SUBORDER: Each order is subdivided into suborders that are based primarily on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences resulting from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is *Fluvent*

TABLE 6.—*Classification of soil series* [1]

Series	Family	Subgroup	Order
Bernardino	Fine, mixed, thermic	Ustollic Haplargids	Aridisols.
Cave	Loamy, mixed, thermic, shallow	Typic Paleorthids	Aridisols.
Cogswell	Fine, mixed, thermic	Pachic Calciustolls	Mollisols.
Comoro	Coarse-loamy, mixed, thermic	Cumulic Haplustolls	Mollisols.
Comoro, alkali variant	Coarse-loamy, mixed, thermic	Cumulic Haplustolls	Mollisols.
Cowan	Sandy, mixed, thermic	Typic Torrifluvents	Entisols.
Crot	Fine-loamy, mixed, thermic	Aquic Natrustalfs	Alfisols.
Dry Lake	Sandy over loamy, mixed, thermic	Typic Calciorthids	Aridisols.
Duncan	Fine, mixed, thermic	Typic Nadurargids	Aridisols.
Duncan, shallow variant	Fine, mixed, thermic	Typic Nadurargids	Aridisols.
Elfrida	Fine-loamy, mixed, thermic	Pachic Calciustolls	Mollisols.
Forrest	Fine, mixed, thermic	Ustollic Haplargids	Aridisols.
Frye	Fine, mixed, thermic	Typic Durargids	Aridisols.
Gothard	Fine-loamy, mixed, thermic	Typic Natrargids	Aridisols.
Grabe	Coarse-loamy, mixed, thermic	Cumulic Haplustolls	Mollisols.
Guest	Fine, mixed, thermic	Cumulic Haplustolls	Mollisols.
Karro	Fine-loamy, carbonatic, thermic	Ustollic Calciorthids	Aridisols.
Kimbrough	Loamy, mixed, thermic, shallow	Petrocalcic Calciustolls	Mollisols.
Kimbrough, shallow over bedrock variant.	Loamy-skeletal, mixed, thermic, shallow	Paleorthidic Calciustolls	Mollisols.
Luzena	Clayey, montmorillonitic, mesic	Lithic Argiustolls	Mollisols.
Luzena, very cobbly subsoil variant	Clayey-skeletal, mixed, thermic	Lithic Ustollic Haplargids	Aridisols.
McAllister	Fine-loamy, mixed, thermic	Ustollic Haplargids	Aridisols.
Pima	Fine-silty, mixed, thermic	Cumulic Haplustolls	Mollisols.
Pridham	Fine, mixed, thermic	Typic Natraquolls	Mollisols.
Sonoita	Coarse-loamy, mixed, thermic	Typic Haplargids	Aridisols.
Stewart	Coarse-loamy, mixed, thermic	Typic Durorthids	Aridisols.
Tubac	Fine, mixed, thermic	Typic Paleargids	Aridisols.
Vinton	Sandy, mixed, thermic	Typic Torrifluvents	Entisols.

[1] Placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

(*fluv* meaning composed of recent alluvium, and *ent*, from Entisol).

GREAT GROUP: Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is Torrifluvents (*Torri* meaning inadequate moisture to mature a crop without irrigation, *fluv* for recent alluvium, and *ent*, from Entisols).

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Torrifluvents (a typical Torrifluvent).

FAMILY: Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or on the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae (see table 6). An example is the sandy, mixed, thermic family of Typic Torrifluvents.

SERIES: The series consists of soils that formed in a particular kind of parent material and have genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile. Among these characteristics are color, texture, structure, consistence, reaction, and mineralogical and chemical composition.

New soil series must be established and concepts of some established series, especially older ones that have been used little in recent years, must be revised in the course of the soil survey program across the country. A proposed new series has tentative status until review of the series concept at the State, regional, and national levels of responsibility for soil classification results in a judgment that the new series should be established. Most of the soil series described in this publication have been established earlier.

Laboratory Analyses

Analyses of selected soils in the survey area are given in tables 7 and 8. The Dry Lake, Frye, and Gothard soils are described in the section "Descriptions of the

Soils," and the Karro, Kimbrough, and Tubac soils are described in this section. The profiles of the Karro, Kimbrough, and Tubac soils are given in this section. These soils differ somewhat from those described as representative of their respective series, but they are within the range defined for each series. All analyses were made on air-dry samples of the fraction less than 2 millimeters in size, and results were recalculated to an ovendry basis. Explanations of the analyses used may be found in Soil Survey Investigations Report No. 1 *(13)*.

Table 7 gives physical data of the analyzed soils.

Particle-size distribution indicates gains and losses of soil particles in the horizons of soil profiles. These analyses, therefore, can be used to study such processes as clay movement and weathering in soils. The amount of clay in a sample can also be used to estimate other properties, such as the cation exchange capacity and the amount of water in soils at the wilting point. In soils that disperse well, the clay content is about 2½ times the water content at the permanent wilting point. Particle-size analysis data also help to locate discontinuities that affect the movement of water in soils. They help in identifying kinds of soil and sedimentary deposits and in locating the sources of sediment. They are used to place soils in textural families of the soil classification system. Particle-size distribution is the amount of mineral particles (sand, silt, clay) less than 2.0 millimeters in diameter in a soil sample, and it is usually expressed as weight percentages.

The *Cm* factor of soils is used to make comparisons of soil properties on a volume basis. The Cm factor multiplied by 100 gives the percentage of fine earth fabric in the whole soil. The volume percentage of material more than 2 centimeters in size is the difference between this value and 100. For example, in the table the amount of organic carbon is given on a weight percentage basis. In order to find the amount of grams of organic carbon per cubic centimeter in the surface layer to a depth of 25 centimeters, the weight percentage is multiplied by 25 centimeters and then by the Cm factor.

Calcium carbonate measured in soils may be either in primary or secondary form. Morphology can be used as a guide to the kind of carbonate. For example, that lining pores and coating gravel is secondary, and that in rounded gravel is primary. Much of the carbonate in the clay fraction is secondary, as can be seen from its distribution in the soil profile. Secondary carbonates are carbonates that are reprecipitated from parent rock or primary carbonates. Carbonate clay is the part of the clay-size fraction of the soil sample that is composed of carbonates. Significant amounts of carbonate may be dissolved by ammonium acetate extraction at pH 7. In carbonatic soils either sodium acetate or potassium chloride-triethanolamine, both of which are buffered at pH 8.2, are better extractants for exchangeable bases.

Bulk density is a measure of the weight of soil per unit of volume. It is used to calculate the Cm factor and linear extensibility. Bulk density may also be used to detect soil horizons that limit plant growth. Growth of roots is restricted by densities of moist soil as high as 1.8 grams per cubic centimeter.

Linear extensibility is a measure of the change in the vertical dimensions of the natural fabric of a soil in going from an ovendry state to a moist state (at ⅓ bar). Linear extensibility of the natural fabric approximates the change in volume that the same soil undergoes as it becomes wet if it has been compacted and used as a foundation, because the wider range in moisture content (ovendry to field capacity) of the laboratory sample compensates for the higher density of the compacted foundation material.

Water content of soils at ⅓ bar corresponds fairly closely to field capacity, and that at 15 bar corresponds to the permanent wilting point. Therefore, the differences between the two percentages represents the percentage available for plant growth, or available water capacity. This percentage may be converted to an amount of water by multiplying it by bulk density, the thickness of the layer, and the cross-sectional area.

Clay mineralogy shows the relative abundance of various types of clay in the soil material. The various clays have different properties, and these differences affect the behavior of the soils. Montmorillonitic clays have a cation exchange capacity of about 80 to 150 milliequivalents per 100 grams; illitic clays, 10 to 40; kaolinitic clays, 3 to 15; and zeolites, 100 to 300. Many of the clays in soils of the basin are a mixture of montmorillonite and illite and have a cation exchange capacity of 40 to 80. Clay mineralogy was determined by methods described in Soil Survey Investigations Report No. 1 (*13*).

Table 8 gives chemical data of the analyzed soils.

Reaction, expressed as pH, was measured with a glass-electrode pH meter at a 1:1 water ratio.

Organic matter is estimated in soils by multiplying the amount of organic carbon by the factor 1.732. Organic carbon was determined by acid dichromate digestion and ferrous sulfate titration. Organic matter has a cation exchange capacity of several hundred milliequivalents per 100 grams, and therefore it adds considerably to the cation exchange capacity of soils. Much of its cation exchange capacity, however, is realized only at high pH. Likewise it increases the amount of water held by soils, but only a small part of this is in the range between 15 bar and ⅓ bar.

Cation exchange capacity of a soil measures the capacity of its clay and organic fractions to store cations in exchangeable form. The measurement has a number of important uses. In combination with the clay content, it can be used to determine the dominant kind of clay in a soil. In combination with the percentages of clay and 15-bar water content, it can be used to detect amorphous materials or materials, except for glass, that retain large amounts of water and have large cation exchange capacities relative to the measured amount of clay. Cation exchange capacity was obtained by saturating and leaching the soil sample with an ammonium acetate solution. Water, granular zinc, and 1N sodium hydroxide were added to the sample and distilled in a 4-percent boric acid solution. The solution was then titrated with hydrochloric acid.

The sum of bases is the total amount of calcium, magnesium, sodium, and potassium extracted from the sample by ammonium acetate (at pH 7). In soils that contain calcium and magnesium carbonates, this method is used because the lower pH of ammonium acetate extracts a little calcium and magnesium from

TABLE 7.—*Physical*

[Tests performed by Soil Survey Laboratory, Riverside, California.

Soil and laboratory sample number	Horizon	Depth	Particle-size distribution				Cm
			Sand		Silt	Clay	
			Total sand	Sand coarser than very fine			
		In	*Pct*	*Pct*	*Pct*	*Pct*	
Dry Lake: S69Ariz-2-14	Ap	0–9	88.5	78.2	6.5	5.0	1.00
	C1	9–24	85.5	73.3	7.1	7.4	1.00
	IIC2ca	24–35	57.9	47.1	19.5	22.6	1.00
	IIC3ca	35–60	40.9	32.3	29.2	29.9	1.00
Frye: S64Ariz-2-18	A11	0–2	75.7	60.7	18.7	5.6	.99
	A12	2–6	66.1	53.5	23.6	10.3	.98
	A3	6–9	58.3	47.3	28.7	13.0	.98
	B1	9–12	50.3	39.9	32.5	17.2	.99
	B21t	12–17	27.1	20.0	22.5	50.4	.99
	B22t	17–23	27.3	20.2	25.0	47.7	.94
	B23tsica	23–26	36.2	25.2	37.9	25.9	.94
	C1sicam	26–33	—	—	—	—	.94
	C2sicam	33–38	—	—	—	—	1.00
	C3sica	38–56	37.2	20.8	48.3	14.5	1.00
	C4	56–80	48.2	28.7	36.9	14.9	1.00
	C5	80–93	70.7	57.9	17.5	11.8	—
Gothard: S64Ariz-2-20	A11	0–2	68.7	45.8	23.0	8.3	1.00
	A12	2–5	56.0	34.7	34.4	9.6	1.00
	B21t	5–11	41.4	26.4	29.3	29.3	1.00
	B22tca	11–24	39.2	23.0	36.5	24.3	.99
	B23tca	24–42	41.6	26.9	30.1	28.3	.97
	C1ca	42–51	69.8	62.9	14.0	16.2	.93
	C2ca	51–80	75.7	65.0	14.1	10.2	.96
Karro:[3] S64Ariz-2-23	Ap1	0–7	48.4	35.7	33.5	18.1	0.97
	Ap2	7–12	44.5	32.8	35.6	19.9	0.97
	C1ca	12–20	30.7	21.7	33.8	35.5	0.98
	C2ca	20–27	23.7	16.6	35.0	41.3	—
	C3ca	27–42	30.1	20.6	30.1	39.8	1.00
	C4ca	42–56	26.7	20.5	24.0	49.3	—
	C5ca	56–75	21.7	17.0	37.1	41.2	1.00
Kimbrough: S64Ariz-2-26	A1	0–11	48.7	38.6	34.7	16.6	—
	C1cam	11–15	—	—	—	—	—
	IIC2	15–21	51.9	40.2	32.0	16.1	—
	IIIC3ca	21–41	—	—	—	—	—
	IVC4	41–45	85.6	79.8	10.0	4.4	—
Tubac: S64Ariz-2-28	A11	0–2	65.9	52.8	28.7	5.4	0.88
	A12	2–6	62.3	49.3	28.5	9.2	0.78
	A3	6–11	56.1	46.7	27.2	16.7	0.70
	B21t	11–21	26.3	22.6	15.0	58.7	0.83
	B22tca	21–35	41.5	38.4	10.4	48.1	0.53
	B3tca	35–44	61.1	56.1	15.2	23.7	0.60
	C	44–70	83.0	81.3	6.1	10.9	0.62

[1] Amounts of the kinds of clay are indicated by numbers corresponding to relative terms: 1 means a trace of the clay; 2, a small amount; 3, a moderate amount; 4, abundant; and 5, a dominant amount.

these sources, resulting in slightly higher extractable calcium and magnesium values. In soils that lack salt the extractable bases are equivalent to *exchangeable bases,* but in soils that contain salt, the bases in the saturation extract must be subtracted from the extractable bases to find the amount of exchangeable bases.

Iron is commonly extracted and measured in soils by the dithionite citrate method or by sodium pyrophosphate. Dithionite citrate extracts iron that is not in primary minerals as well as most iron present in organic compounds. Sodium pyrophosphate is more selective and removes mostly the iron from the organic compounds.

Sodium saturation is one way of expressing the amount of sodium in soils. Sodium saturation calculated by using the cation exchange capacity as measured by either the ammonium acetate or sodium acetate methods gives comparable results for horizons low in organic matter. The variable charge of organic

analyses of selected soils

Absence of an entry means that no value was determined]

Calcium carbonate		Bulk density at 1/3 bar	Linear extensibility	Water content at—		Clay mineralogy [1]			
Clay-size (soil fraction <0.002 mm)	Total (soil fraction <2 mm)			1/3 bar	15 bar	Mont-morillonite	Vermiculite	Mica	Kaolinite
Pct	*Pct*	*G per cm³*	*Pct*	*Pct*	*Pct*				
	1	1.46	0.5	5.5	3.1				
	2	1.63	.2	5.5	4.4			3	
14	29	1.53	1.1	17.7	10.9				
15	39	1.28	2.3	25.3	16.0			2	
					2.7				
		1.67	.2	8.4	3.8			3	1
		1.62	.8	9.6	4.4				
		1.60	1.6	11.7	5.5				
		1.43	6.0	25.7	15.4				
		1.44	6.2	27.4	15.7	3		3	1
	12				17.4	4		4	2
	17				14.0				
	26	1.55	.3	18.1	11.4				
1	16	1.52	1.4	18.2	8.2	4		3	2
	1	1.53	1.8	18.5	7.7				
	([2])	1.66	1.1	11.2	6.2				
	3	1.57	.1	11.5	4.3	2		2	
	([2])	1.66	.5	13.1	4.9				
1	6	1.27	7.2	32.9	15.1	5		3	1
5	15	1.58	3.0	19.0	11.0	5		2	1
12	25	1.71	4.1	18.9	9.5	4		3	1
	2	1.51	4.8	23.8	10.0				
	1	1.40	4.4	26.3	7.2				
6	22	1.31	1.1	26.5	14:0				
7	24	1.28	1.2	27.8	14.2	3	3	3	1
18	35	1.29	2.3	27.9	14.4				
26	47				17.4	3	3	3	1
23	48	1.22	2.7	31.3	19.7				
30	49				15.2				
37	79	1.50	1.5	20.1	10.3				
16	5				9.8	5		3	1
60					12.8				
26	7				8.9	5		2	1
27					3.2				
1					3.9	5		1	1
		1.59	.2	11.1	3.9				
		1.48	.3	13.2	4.7	3		3	3
		1.43	1.1	18.0	7.0	3		3	
		1.20	8.3	40.1	21.6				
1	3	1.27	3.2	31.0	19.0	3		4	1
([2])	([2])	1.40	2.2	21.3	10.8				
([2])	([2])	1.38	.6	17.6	6.7	5		3	1

[2] Trace.
[3] This Karro soil is a taxadjunct to the Karro series; it is a Ustollic Calciorthid, coarse-loamy, carbonatic, thermic.

matter causes the cation exchange capacity measured by sodium acetate to be high, and thus the sodium saturation using this value is low as compared to that using the ammonium acetate cation exchange capacity. Sodium saturation percentages of 15 and above are harmful to most plants.

Chloride and sulfate were determined by procedures outlined in Soil Survey Investigations Report No. 1 (*13*).

Sodium adsorption ratio is another measure of the amount of sodium in soils. The sodium adsorption ratio is a measure of the amount of sodium in solution to the amount of calcium and magnesium in solution. Unlike the sodium saturation percentage it is not influenced by the solution of zeolites or carbonates. Hence, the sodium adsorption ratio is a more sensitive measure of the influence of sodium upon plant growth in a particular soil than is the sodium saturation percentage.

Water content at saturation is a measure of pore space in soils. Soils that have a high water content

TABLE 8.—*Chemical*

[Tests performed by Soil Survey Laboratory, Riverside, California.

Soil series and laboratory sample number	Horizon	Depth	Reaction	Organic matter	Cation exchange capacity	Sum of bases
		In	*pH*	*Pct*	*Meq per 100g*	*Meq per l*
Dry Lake: S69Ariz-2-14	Ap	0–9	7.6	0.83	5.8	8.4
	C1	9–24	7.7	.74	5.9	8.4
	IIC2ca	24–35	7.6	.20	4.9	9.2
	IIC3ca	35–60	7.6	.04	6.6	8.3
Frye: S64Ariz-2-18	A11	0–2	6.3		4.2	4.3
	A12	2–6	6.0	.60	5.7	5.6
	A3	6–9	6.6	.50	6.9	7.2
	B1	9–12	7.1	.45	8.5	8.5
	B21t	12–17	7.4	.45	24.0	25.0
	B22t	17–23	7.9	.34	24.9	30.8
	B23tsica	23–26	7.9	.48	26.0	41.4
	C1sicam	26–33	8.2	.62	23.4	32.3
	C2sicam	33–38	8.4	.29	16.1	33.9
	C3sica	38–56	8.4	.24	13.8	28.6
	C4	56–80	8.3	.06	14.6	24.8
	C5	80–93	8.3	.01	11.8	13.4
				.01		
Gothard: S64Ariz-2-20	A1	0–2	8.7		8.2	21.4
	A2	2–5	9.2	.69	9.5	19.2
	B21t	5–11	9.0	.50	20.8	36.4
	B22tca	11–24	9.9	.65	20.3	40.5
	B23tca	24–42	10.0	.22	13.0	33.7
	C1ca	42–51	9.9	.12	14.7	29.5
	C2ca	51–80	9.7	.01	11.3	16.6
Karro:[1] S64Ariz-2-23	Ap1	0–7	7.9	1.45	13.4	29.0
	Ap2	7–12	8.0	1.03	12.8	28.4
	C1ca	12–20	8.1	.51	9.0	24.9
	C2ca	20–27	8.0	.39	9.6	28.8
	C3ca	27–42	8.0	.31	10.4	26.9
	C4ca	42–56	8.1	.22	9.2	25.5
	C5ca	56–75	8.2	.22	3.2	21.8
Kimbrough: S64Ariz-2-26	A1	0–11	----------------	2.94	16.4	32.1
	C1cam	11–15	8.1	.65	5.5	21.4
	IIC2	15–21	8.0	1.35	12.7	28.7
	IIIC3ca	21–41	8.4	.10	4.7	16.0
	IVC4	41–45	8.8	.05	9.6	18.2
Tubac: S64Ariz-2-28	A11	0–2	5.7	.43	5.2	5.5
	A12	2–6	6.3	.57	6.7	7.1
	A3	6–11	7.0	.74	10.2	11.6
	B21t	11–21	7.5	.58	32.6	40.8
	B22tca	21–35	7.9	.34	29.6	43.4
	B3tca	35–44	7.7	.06	19.1	26.2
	C	44–70	7.6	.03	14.0	15.7

[1] This Karro soil is a taxadjunct to the Karro series; it is a Ustollic Calciorthid, coarse-loamy, carbonatic, thermic.

at saturation have a correspondingly high pore space when freely drained of water.

Electrical conductivity is a general measure of the amount of salt in solution. Conductivities above 4 millimhos per centimter (EC x 10^3) restrict the yields of many plants. For conductivities below 10 millmhos per centimeter, the concentration of salts in milliequivalents per liter is about 10 times the conductivity.

Following are representative profiles of the Karro, Kimbrough, and Tubac soils shown in tables 7 and 8.

Representative profile of Kimbrough gravelly loam, about 560 feet south and 150 feet west of the northeast corner of sec. 23, T. 16 S., R. 28 E.; on ridgetop 400 feet east of ranch road, ½ mile north-northeast of the intersection with State Highway 186, 29 miles east-southeast of Willcox:

A1—0 to 11 inches, gray (10YR 5/1) gravelly, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, nonsticky to slightly plastic when wet; many fine and very fine roots; many fine interstitial pores; 30 to 40 percent fine and medium gravel; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

C1cam—11 to 15 inches, white (N 8/0) hardpan, very pale brown (10YR 7/3) when moist; massive and cemented; upper ½ inch is laminar; extremely hard when dry, extremely firm when moist; no roots;

analyses of selected soils

Absence of an entry means that no value was determined]

Exchangeable cations		Sodium adsorption ratio	Water extract from saturated paste		Water content at saturation	Electrical conductivity
Iron	Sodium		Chloride	Sulfate		
Pct	*Pct*		*Meq per l*	*Meq per l*	*Pct*	*Mmho per cm*
0.10	2	-----	-----	-----	-----	0.89
.10	2	-----	-----	-----	-----	.65
.00	2	3	2.7	-----	46.9	.96
.00	24	13	31.8	46.3	82.9	6.20
.50	5	-----	-----	-----	-----	-----
.60	4	-----	-----	-----	-----	-----
.70	3	-----	-----	-----	-----	-----
.80	4	-----	-----	-----	-----	-----
1.20	5	-----	-----	-----	-----	-----
1.10	6	3	8.2	-----	55.0	1.63
.80	9	4	19.0	-----	62.3	2.84
.40	10	5	26.4	-----	47.4	3.70
.40	12	6	16.7	-----	44.8	2.68
.60	12	9	9.9	-----	43.2	2.46
.70	12	6	9.2	-----	42.3	1.74
.60	12	6	6.0	-----	39.2	1.20
.28	21	9	3.4	-----	29.9	1.60
.35	40	18	3.0	-----	27.7	1.25
.40	72	49	8.3	25.5	59.8	4.35
.22	100	197	10.9	138.0	47.0	13.20
.14	104	312	11.9	161.0	41.4	16.70
.23	88	155	7.3	85.2	63.1	10.00
.34	84	98	4.9	35.7	57.6	5.16
-----	6	2	2.0	-----	48.1	1.28
-----	6	2	2.5	-----	50.8	1.32
-----	9	4	2.1	-----	55.9	1.13
-----	8	2	1.8	-----	58.6	1.25
-----	8	2	1.9	-----	61.0	1.29
-----	6	2	2.7	-----	54.7	1.32
-----	25	3	3.3	-----	42.8	1.54
-----	4	1	2.1	-----	50.2	.87
-----	14	1	1.2	-----	43.8	.78
-----	5	1	2.2	-----	44.3	1.10
-----	11	8	4.4	-----	28.4	1.06
-----	17	3	2.7	-----	22.8	1.11
-----	19	-----	-----	-----	23.8	.35
-----	15	-----	-----	-----	28.6	.55
-----	9	1	1.8	-----	32.8	1.34
-----	7	3	7.6	-----	72.2	2.18
-----	12	4	14.0	-----	58.4	2.76
-----	19	7	18.7	-----	37.2	3.45
-----	26	8	13.9	-----	28.7	2.71

common, medium and coarse, tubular pores below a depth of ½ inch; 30 to 40 percent fine and medium gravel; violently effervescent; moderately alkaline; abrupt, irregular boundary.

IIC2—15 to 21 inches, grayish-brown (10YR 5/2) gravelly loam, dark brown (10YR 3/3) when moist; common fine and medium pan fragments that are white (N 8/0) when dry and very pale brown (10YR 7/3) when moist; massive, parting to weak, fine, granular structure; slightly hard when dry, friable when moist, nonsticky and plastic when wet; common fine and very fine roots; many fine interstitial pores; 30 to 40 percent gravel; strongly and violently effervescent; moderately alkaline; abrupt, wavy boundary.

IIIC3ca—21 to 41 inches, white (N 8/0) gravelly lime pan: light brown (7.5YR 6/4) when moist; massive and strongly cemented; extremely hard when dry, extremely firm when moist; few fine roots; common fine, tubular pores; violently effervescent; 40 to 50 percent gravel; moderately alkaline; abrupt, wavy boundary.

IVC4—41 to 45 inches, light brownish-gray (10YR 6/2) very gravelly loamy sand, grayish brown (10YR 5/2) and light gray (10YR 7/2) when moist; thin, white (N 8/0) coatings of lime; single grained; loose when dry, friable when moist, nonsticky and nonplastic when wet; few fine roots; common fine, tubular pores and many interstitial pores; 60 to 70 percent fine and medium gravel; strongly and violently effervescent; moderately alkaline; abrupt, irregular boundary.

Representative profile of Karro loam, 1,075 feet north and 600 feet east of the south quarter corner of sec. 11, T. 16 S., R. 24 E.; 3½ miles east and 14 miles south of Willcox:

Ap1—0 to 7 inches, light brownish-gray (10YR 6/2) loam, dark yellowish brown (10YR 3/4) when moist; massive, parting to moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common fine, medium and coarse roots; many fine interstitial pores; violently effervescent; moderately alkaline; clear, smooth boundary.

Ap2—7 to 12 inches, pale-brown (10YR 6/3) and light-brown (7.5YR 6/4) loam, dark yellowish brown (10YR 3/4) when moist; massive, parting to weak to moderate, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; common fine, medium and coarse roots; many fine interstitial pores; violently effervescent; moderately alkaline; clear, wavy boundary.

C1ca—12 to 20 inches, light-brown (7.5YR 6/4) and pink (7.5YR 7/4) loam, brown (7.5YR 5/4) and light brown (7.5YR 6/4) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; common fine and medium roots; common fine, interstitial and tubular pores; violently effervescent; few fine and medium lime and silica-cemented nodules that are extremely hard and firm; moderately alkaline; gradual, smooth boundary.

C2ca—20 to 27 inches, mottled pinkish-gray (7.5YR 7/2) and pinkish-white (7.5YR 8/2) gravelly heavy loam, light brown (7.5YR 6/4) and pinkish gray (7.5YR 7/2) when moist; massive and weakly cemented; very hard when dry, friable when moist, slightly sticky and plastic when wet; few fine, tubular pores and common interstitial pores; violently effervescent; about 50 percent fine and medium concretions that are extremely hard and very firm; strongly alkaline; gradual, smooth boundary.

C3ca—27 to 42 inches, mottled pink (7.5YR 7/4) and pinkish-white (7.5YR 8/2) gravelly heavy loam, light brown (7.5YR 6/4) and pinkish gray (7.5YR 7/2) when moist; weak, medium and coarse, prismatic structure, parting to moderate, fine and medium, angular blocky; very hard when dry, firm when moist, slightly sticky and plastic when wet; few fine roots; many fine and very fine, tubular pores and common interstitial pores; about 35 percent fine and medium or very fine and hard concretions; violently effervescent; strongly alkaline; clear, wavy boundary.

C4ca—42 to 56 inches, similar to C3ca but containing 50 to 60 percent concretions of very gravelly heavy loam.

C5ca—56 to 75 inches, mottled 75 percent white (N 8/0) and 25 percent pinkish-gray (7.5YR 7/2) clay loam, pinkish white (7.5YR 8/2) and pinkish gray (7.5YR 7/2) when moist; massive and weakly cemented, parting to weak, fine and medium, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; no roots; common fine, interstitial pores, many fine and very fine tubular pores, and few medium, tubular pores; violently effervescent; strongly alkaline.

Representative profile of Tubac fine gravelly loam, 820 feet west and 375 feet north of the east quarter corner of sec. 18, T. 12 S., R. 25 E.; 9 miles north and ¾ mile east of Willcox:

A11—0 to 2 inches, light-brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 4/4) when moist; weak, medium and coarse, platy structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; common fine and medium roots; few fine, tubular pores and many fine, interstitial pores; 10 percent fine gravel; strongly acid; abrupt, smooth boundary.

A12—2 to 6 inches, reddish-brown (5YR 5/3) gravelly heavy sandy loam, reddish-brown (5YR 4/3) when moist; weak, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and very fine roots; few fine tubular pores and common fine, interstitial pores; 30 percent fine gravel; strongly acid; clear, smooth boundary.

A3—6 to 11 inches, reddish-brown (5YR 5/3) gravelly clay loam, reddish brown (5YR 4/3) when moist; weak, fine and medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common fine and medium roots; common fine, tubular pores and many fine, interstitial pores; few thin, clay films on faces of peds and in pores; 30 percent fine gravel; mildly alkaline; abrupt, wavy boundary.[1]

B21t—11 to 21 inches, reddish-brown (5YR 4/3) (5YR 4/4 when crushed) gravelly clay, same color when moist; moderate, medium, prismatic structure, parting to moderate, fine and medium, angular blocky; very hard when dry, friable when moist, sticky and very plastic when wet; common exped, flattened, fine roots; few fine, tubular pores and many exped pores; thin, continuously clay films on faces of peds and lining pores; 20 percent fine and medium gravel; noneffervescent; moderately alkaline; clear, wavy boundary.

B22tca—21 to 35 inches, reddish brown (5YR 5/4) gravelly clay, reddish brown (5YR 4/4), light reddish brown (5YR 6/3) and black when moist; pink (5YR 7/3) common fine, faint mottles (weathered gravel), lime flecks, and thin, patchy lime coatings on gravel; common very fine mottles of black; massive, parting to moderate, fine and medium, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; few fine roots; common fine, tubular pores and many fine, interstitial pores; many thin clay films on faces of peds, gravel, and pore linings; 30 percent fine to coarse gravel; slightly effervescent with HCl in matrix and strongly effervescent in mottles and coatings; moderately alkaline; gradual, wavy boundary.

B3tca—35 to 44 inches, reddish-brown (5YR 5/3 and 5/4) gravelly sandy clay loam, reddish brown (5YR 4/4) when moist; massive; very hard when dry, friable when moist, sticky and plastic when wet; few fine roots; common fine, tubular and interstitial pores; few thin clay films on faces of peds, in pores, and as bridges; 35 percent fine to coarse gravel and 5 percent cobblestones; slightly effervescent in spots (a few gravel coatings are strongly effervescent); moderately alkaline; gradual, wavy boundary.

C—44 to 70 inches, light reddish-brown (5YR 6/3) very gravelly loamy sand, reddish brown (5YR 4/3) when moist; massive; very hard when dry, friable when moist, nonsticky and nonplastic when wet; no roots; many fine, interstitial pores; noneffervescent; moderately alkaline.

Additional Facts About the Area

This section provides information about early settlement of the Area; discusses land use and water supply; describes its geology, relief, and drainage; and gives facts about the climate.

Farming

Abandoned irrigation ditches and corn-grinding metates provide evidence that farming was practiced in the Willcox Area during prehistoric times. The early settlers, however, took little interest in farming except to supplement cattle raising.

Livestock raising was started in the valley in the late

[1] A very thin intermittent pinkish-gray (5YR 6/2) layer (dark reddish gray [5YR 4/2] when moist) is between A3 and B21t horizons.

1600's by Spaniards who were led by Father Kino, but because of frequent Indian raids, ranching was unsuccessful. In 1849 during the California Gold Rush large herds of cattle were driven through the Area. The abundance of grass and the mountain springs lured many of the drivers to return and establish ranches. Completion of the Southern Pacific Railroad through the valley in 1880 was a great incentive to the growth of the cattle industry. Miners and soldiers provided most of the local market, and most of the cattle raised were shipped out of the Area. Willcox soon became known as the leading cattle-shipping point in the nation. Historical records indicate that one and one-half million cattle were in the valley by 1891. Sometimes as many as nine trainloads of cattle were shipped in a day, and several thousand head were held on the range awaiting trains.

Completion of the Southern Pacific Railroad and growth of mining and smelting centers contributed to an increase in the population of settlers from the East. Unusually heavy rains in 1905, 24 inches of rainfall instead of the normal 12 inches, aroused interest in dryland farming. A group of homesteaders established the first farming community, the Kansas Settlement, east of the Willcox Playa. The site was favorable for farming because it was nearly level and received runoff from streams flowing down the alluvial fan from the southeast. Where pumps were available, water was obtained from a shallow depth.

The heavy rains continued, and by 1910 most of the better land in the Area was homesteaded. Grain sorghum, beans, and corn were the favored crops because they thrived and matured rapidly during the hot summer rainy season. Rains began to diminish in 1908. In the following years only those who practiced efficient methods of dryland farming or who were able to obtain additional water by diverting floodwater or by pumping were able to continue farming. Many converted their farms to cattle ranches or left the Area.

In 1906 an attempt to develop an inexpensive source of power for pumping irrigation water failed when a huge solar motor, involving a 36-foot diameter mirror containing 4,800 glass reflectors, was destroyed by hail. Windmill pumps and pumps driven by small gasoline engines were gradually replaced by larger motor-driven pumps. Such crops as alfalfa, small grain, and fruits, which require water in great quantities or for long periods, were introduced. As efficiency of motors for pumps improved, the farmlands expanded upward on the slopes, where the ground water is deeper (*6, 11*).

Water Supply

All water for domestic, municipal, industrial, and farm use is obtained from ground water. The water is pumped from vast alluvial deposits that underlie the Sulphur Spring Valley.

Estimates based on records of electric power plants, pumping plants, and other sources indicate that about 291,000 acre-feet of ground water was pumped in the Willcox Basin in 1969 (*2*).

Geology, Relief, and Drainage[7]

The Willcox Area lies within the Mexican Highland section of the Basin and Range Physiographic Province. It is situated in a large closed basin that occupies the northern part of the Sulphur Spring Valley. Lying between two maturely dissected, fault-block mountain ranges, Sulphur Spring Valley is a broad, northwest-trending, debris-filled valley. The closed basin drains inward from the mountains into the Willcox Playa. The Area is strongly affected by the total runoff- and sediment-contributing area of the Willcox Playa. For this reason, a discussion of the geology of the total drainage area of the playa follows.

The drainage area is bounded on the east by the Pinaleno, Dos Cabezas, and Chiricahua Mountains and on the west by the Galiuro, Winchester, Little Dragoon, and Dragoon Mountains. The drainage divides on the north and south are poorly defined. The southern divide occurs where alluvium has buried all but scattered pinnacles of an extension of the Swisshelm Mountains. The valley narrows to the north and ends at a low divide in southwestern Graham County. An ancient alluvial fan that blocks the valley forms the northern divide.

The mountains rise abruptly above the nearly level to gently sloping valley floor, the east side rising higher than the west. The highest peak is Mount Graham in the Pinaleno Mountains, with an elevation of 10,713 feet. Bassett Peak in the Galiuro Mountains is the highest point on the west side, at 7,650 feet. The elevation at the edge of the Willcox Playa is 4,135 feet.

The present mountains are composed primarily of igneous and metamorphic rocks, but the original mountains were characterized by large masses of sedimentary rock, most of which have been removed by subsequent erosion.

The lower, older alluvium in the Willcox basin is late Tertiary to early Quaternary in age and consists of weakly to moderately consolidated clay, silt, sand, sandstone, gravel, and conglomerate. Generally, the material in these deposits grades from boulders, cobbles, and gravel at the mountain foot slopes to the moderately fine textured soils toward the bottom of the basin. The bed of the Willcox Playa is characterized by deposits of highly saline clay.

One or more lakes occupied the Willcox basin while the upper part of the fill was being deposited, and thick beds of clay were laid down in the lake or lakes. Shoreline fluctuations resulted in the interfingering of sand and gravel with the lake clay. The shoreline of ancient Lake Cochise is still partly preserved in the form of ancient beach ridges near the present playa. The Willcox Playa lies within the area of the larger Lake Cochise.

After most of the valley fill had accumulated, basaltic lava was extruded near the mountain bases. The lava flowed onto and became interbedded with the valley alluvium. After extrusion of the basalt, pediments were formed on both the basalt and the valley alluvium. In parts of the basin, pediment surfaces also developed on older rocks. Later, these pediments were partially dissected by erosion. While the pediments were being formed and later dissected, the eroded material was being deposited in the lower parts of the basin.

At present, the wind is depositing sand as dunes on the north and east sides of the playa and near some of the small pinnacles along the southern divide. Erosion is continuing, and eroded materials are being

[7] Prepared by CHARLES D. CLARKE, geologist, river basins, Soil Conservation Service, Phoenix, Arizona.

transported from higher elevations and deposited at lower elevations.

Water for irrigation in the Willcox Area is pumped from the Quaternary-Tertiary alluvium. Well yields range from about 200 to more than 3,500 gallons per minute, depending primarily on the thickness of penetrated gravel and sand beds below the water table. The depth to the water table, which has been increasing gradually since heavy pumping began in the mid-1950's, ranges from about 20 feet near the playa to more than 300 feet at higher positions.

The principal use of the water is for irrigating grain sorghum and other crops. Irrigated acreage has increased rapidly since the early 1950's. About 150,000 acres are now irrigated.

Most of the ground water is of excellent quality (*3,9*). In only a few areas is the water known to be of poor quality.

Since pumping of water started, the water table has steadily dropped. Records kept for individual wells indicate a drop of 5 to 8 feet per year. Some of the water is replaced by rain and snow that falls within the area, but most of the recharge comes from outside the Area. The exact amount of ground water available for use is not known.

In many places throughout the survey area, "earth cracking" or "subsidence fissures" have developed. This subsidence of the earth is believed to have been caused by the lowering of the water table. Many of these areas were recognized during the course of the survey, and the cracks are shown on the map sheets by a special symbol. These cracks are still developing.

Climate [8]

The climate of this part of Arizona is moderated somewhat by its elevation and by the nearby mountains. More than half of the total annual precipitation falls from July through September (table 9). At this

[8] By PAUL C. KANGIESER, climatologist for Arizona, U.S. Weather Service, U.S. Department of Commerce.

TABLE 9.—*Temperature and precipitation*

Willcox [Elevation, 4,190 feet]

Month	Temperature: Average daily high [1]	Temperature: Average daily low [1]	Two years in 10 will have 4 days with at least—[2] Maximum temperature equal to or higher than—	Two years in 10 will have 4 days with at least—[2] Minimum temperature equal to or lower than—	Precipitation: Average monthly total [1]	One year in 10 will have—[2] Less than—	One year in 10 will have—[2] More than—
	°F	°F	°F	°F	In	In	In
January	58	25	71	11	0.8	([3])	1.8
February	63	27	76	14	.6	([3])	1.5
March	68	31	80	19	.6	([3])	1.4
April	78	37	88	25	.3	0	.9
May	86	43	97	30	.1	0	.5
June	95	52	103	39	.4	([3])	1.7
July	95	63	104	56	2.6	1.1	4.8
August	92	60	99	53	2.7	.4	5.0
September	90	53	98	41	1.2	([3])	3.3
October	80	41	90	27	.6	([3])	2.0
November	68	30	79	19	.4	([3])	1.2
December	59	25	71	13	1.0	([3])	3.5
Year	78	41	[4] 105	[5] 8	11.3	6.6	16.4

Pearce [Elevation, 4,420 feet]

Month	Average daily high [1]	Average daily low [1]	Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—	Average monthly total [1]	Less than—	More than—
January	60	30	72	17	0.7	([3])	1.6
February	62	31	76	19	.7	([3])	1.4
March	66	36	80	25	.6	([3])	1.1
April	83	43	87	33	.2	0	.6
May	85	49	95	39	.2	0	.4
June	94	57	103	49	.5	([3])	1.4
July	94	64	101	60	3.0	1.4	4.3
August	91	62	98	58	3.2	.7	5.9
September	88	57	96	48	1.1	([3])	3.5
October	80	46	90	37	.6	([3])	1.2
November	71	35	80	27	.4	([3])	.9
December	61	29	72	19	.9	([3])	2.4
Year	78	45	[4] 104	[5] 13	12.1	8.6	16.5

[1] Period of record: 1941–70 at Willcox, 1944–70 at Pearce.
[2] Period of record: 1949–70.
[3] Trace.
[4] Average annual highest temperature.
[5] Average annual lowest temperature.

time of the year very moist air from the Gulf of Mexico flows up the Sulphur Spring Valley from the southeast. As this air rises over the surrounding mountains, it becomes unstable, releasing much of its energy in the form of moderate to heavy thunderstorms that often spread over most of the Sulphur Spring Valley during the afternoon and early evening.

Most of the rest of the precipitation in this part of the State is received during the period from October through March. This cool-season precipitation, a small fraction of which falls as snow, is usually associated with storms that move into the State from the Pacific Ocean. A large part of the moisture of these storms, however, is precipitated in the mountains to the west of the Sulphur Spring Valley, so that only moderate amounts of moisture can be expected in the Valley itself.

Near Willcox, 2.73 inches of precipitation in 24 hours will fall once in 10 years, and 4.14 inches may be expected once in 100 years. In 1 hour, 1.77 inches may be expected once in 10 years and 2.62 inches once in 100 years.

About 1 year out of 5, moisture from a deteriorating tropical storm to the south or southwest enters the State by way of the Gulf of California, producing heavy precipitation early in fall. Such precipitation, though rare, usually falls in plentiful amounts and sometimes lasts for several days, in contrast to the summer thunderstorm precipitation, which usually lasts for only a few hours.

Skies are usually partly cloudy on summer afternoons, and temperatures above 100° F are unusual. After sunset, skies usually clear and temperatures drop about 30° by sunrise the following morning. Winters are characterized by mild, clear days and chilly nights and near-freezing or subfreezing temperatures early in the morning. During the winter the diurnal temperature range is also 30° or more. A temperature as low as 0° in this part of the State is quite rare and is observed only about once in 50 years. Data on dates of frost are given in table 10.

TABLE 10.—*Probabilities of last freezing temperatures in spring and first in fall*

Willcox
[Period of record 1941–65]

Probability	Dates for given probability and temperature				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	March 23	April 12	April 25	May 7	May 26
2 years in 10 later than	March 11	March 30	April 17	April 30	May 19
5 years in 10 later than	February 11	March 4	March 31	April 15	May 3
Fall:					
1 year in 10 earlier than	November 10	November 4	October 27	October 20	October 11
2 years in 10 earlier than	November 21	November 10	November 1	October 25	October 15
5 years in 10 earlier than	December 15	November 22	November 13	November 4	October 24

Pearce
[Period of record 1950–70]

Probability	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	February 22	March 16	March 30	April 15	May 17
2 years in 10 later than	February 13	March 8	March 21	April 8	May 7
5 years in 10 later than	January 23	February 19	March 6	March 27	April 19
Fall:					
1 year in 10 earlier than	December 7	November 17	November 8	November 1	October 21
2 years in 10 earlier than	December 13	November 25	November 14	November 8	October 26
5 years in 10 earlier than	----------	December 14	November 28	November 18	November 5

Prevailing winds blow in an upslope direction along the Sulphur Spring Valley during the warmer part of the day and downslope at night. The strongest winds are associated with thunderstorms in summer. They are usually short and may come from any direction.

Evaporation rates are highest during May and June, and the average annual lake evaporation in this part of the State is about 64 inches.

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Glossary

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvial fan. A sloping, fan-shaped deposit of sand, gravel, and fine material dropped by a stream where its gradient lessens abruptly, as where it emerges from an upland onto a plain.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity. The capacity of a soil to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity (about 1/3 atmosphere of tension) and the amount of soil water at the wilting point of most plants (about 15 atmospheres of tension). In this survey four classes of available water capacity are used: *High*, more than 7.5 inches of water available above a depth of 60 inches or above a root-restricting layer; *moderate*, 5.0 to 7.5 inches; *low*, 2.5 to 5.0 inches; and *very low*, less than 2.5 inches.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Depth, soil. See Effective rooting depth.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Three different classes of natural soil drainage are recognized in this Area.

Well-drained soils are commonly intermediate in texture, although soils of other textural classes may also be well drained. Water is removed from the soil readily but not rapidly. The soils are nearly free of mottling.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. Water is removed from the soil somewhat slowly, so that the profile is wet for a small but significant part of the time. Mottles are common in the B and C horizons.

Somewhat poorly drained soils commonly have a slowly permeable layer in the profile, a high water table, additions of water through seepage, or a combination of these conditions. Water is removed from the soil slowly enough to keep it wet for significant periods but not all the time. Evidence of gleying and mottling in the B horizon is common.

Effective rooting depth. Depth to a claypan, bedrock, hardpan, or other layer in the soil that would stop or hinder the penetration of roots. Depth classes are *deep*, more than 40 inches; *moderately deep*, 20 to 40 inches; *shallow*, 10 to 20 inches; and *very shallow*, less than 10 inches.

Effervescence. The fizz, or bubbling, observed when dilute hydrochloric acid is applied to a soil containing free carbonates. The degree of effervescence is divided into four classes: *noneffervescent, slightly effervescent, strongly effervescent,* and *violently effervescent.*

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material may be sandy or clayey, and it may be cemented by iron oxide, silica, calcium carbonate, or other substance.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Igneous rock. Rock produced by the cooling of melted mineral material; examples are granite, andesite, diorite, and basalt.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Furrow.—Water is applied in small ditches made by cultivation implements used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Irrigation water management. The use ‹ ıd management of irrigation water in which quantity of water used for each irrigation is determined by the water-holding capacity of the soil and the need of the crop, and in which the water is applied at a rate and in such a manner that the crop can use the water efficiently and significant erosion is avoided.

Leaching. The removal of soluble material from soil by percolating water.

Leveling (of land). The reshaping, or modification, of the soil surface to a planned grade to permit uniform distribution of irrigation water without erosion or to provide proper surface drainage.

Lime. Chemically, lime is calcium oxide (CaO), but its meaning has been extended to include all limestone-derived materials applied to neutralize acid soil. Agricultural lime can be obtained as ground limestone, hydrated lime, or burned lime, with or without magnesium minerals. Basic slag, oystershells, and marl also contain calcium.

Metamorphic rock. Rock that formed in solid state in response to pronounced changes in temperature, pressure, and chemical environment. The process takes place, in general, deep in the crust of the earth below the zone of weathering and cementation.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability, soil. The quality of a soil that enables water or air to move through it. Permeability of a soil may be limited by the presence of one nearly impermeable horizon even though others are permeable. Terms used to describe permeability are *very slow,* water moves downward at a rate of less than 0.06 inches per hour; *slow,* 0.06 to 0.20 inches per hour; *moderately slow,* 0.20 to 0.63 inches per hour; *moderate,* 0.63 to 2.00 inches per hour; *moderately rapid,* 2.00 to 6.30 inches per hour; *rapid,* 6.30 to 20.0 inches per hour; and *very rapid,* more than 20.0 inches per hour.

Piping, soil. Removal of soil material through subsurface flow channels or "pipes" developed by seepage water.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Saline-alkali soils. A soil that contains a harmful quantity of salts, a high degree of sodium, or both so distributed in the profile that growth of most crop plants is less than normal.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Sedimentary rock. Rock composed largely of particles deposited from suspension in water. The chief sedimentary rocks are conglomerate, from gravel; sandstone, from sand; shale, from clay; and limestone, from soft masses of calcium carbonate.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slope. The amount of change in elevation per unit distance, generally expressed as percentage, that is, the number of feet rise in 100 feet run.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface layer. A term used in nontechnical soil description for one or more layers above the subsoil. Generally the A horizon.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which plants (specifically sunflower) wilt so much that they do not recover when placed in a dark, humid atmosphere.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs. In referring to a capability unit or range site, read the introduction to the section it is in for general information about its management. Other information is given in tables as follows:

Acreage and extent, table 1, page 5.
Estimated yields, table 2, page 35.
Engineering uses of the soils, tables 3 and 4, pages 42 through 55.

Map symbol	Mapping unit	Described on page	Capability unit Irrigated Symbol	Page	Capability unit Dryland Symbol	Page	Range site Name	Page
BeC	Bernardino complex, 0 to 10 percent slopes	6	IIIe-8	32	VIe-1	34	Loamy Upland	39
Ca	Cave gravelly loam	6	------	--	VIIs-1	34	Caliche Upland	39
Cc	Cogswell clay loam	7	IIIs-8	33	VIIs-1	34	Saline Bottom	36
Ce	Cogswell clay loam, alkali	7	IIIs-9	33	VIIs-1	34	Saline Bottom	36
Cg	Cogswell clay	7	IIIs-3	32	VIIs-1	34	Saline Bottom	36
CmA	Comoro sandy loam, 0 to 2 percent slopes	8	IIs-7	32	VIs-1	34	Sand Upland	38
CnA	Comoro gravelly sandy loam, 0 to 2 percent slopes	8	IIIs-7	32	VIs-1	34	Sand Upland	38
CnC	Comoro gravelly sandy loam, 5 to 10 percent slopes	8	IIIe-7	32	VIe-1	34	Sand Upland	38
Co	Comoro sandy loam, alkali variant	9	------	--	VIIe-1	34	Sand Upland	38
Cs	Cowan sandy loam	9	IIIs-7	32	VIe-1	34	Sand Upland	38
Ct	Crot sandy loam	10	------	--	VIIw-1	34	Saline Bottom	36
Dr	Dry Lake loamy sand	11	IIIe-8	32	VIe-1	34	Sand Upland	38
Du	Duncan loam	12	------	--	VIIs-1	34	Saline Bottom	36
Dv	Duncan loam, shallow variant	13	------	--	VIIw-1	34	Saline Bottom	36
Ef	Elfrida silty clay loam	13	I-1	31	VIc-1	34	Loam Upland	39
FoA	Forrest loam, 0 to 2 percent slopes	14	IIIs-8	33	VIs-1	34	Loamy Upland	39
FrA	Forrest gravelly sandy clay loam, 0 to 2 percent slopes	14	IIIs-8	33	VIs-1	34	Loamy Upland	39
FrB	Forrest gravelly sandy clay loam, 2 to 5 percent slopes	14	IIIe-8	32	VIe-1	34	Loamy Upland	39
Fy	Frye sandy loam	15	IIIs-5	32	VIs-1	34	Loamy Upland	39
Go	Gothard fine sandy loam	16	------	--	VIIs-1	34	Saline Bottom	36
Gr	Grabe sandy loam	17	I-1	31	VIc-1	34	Loam Bottom	38
Gs	Grabe loam	17	I-1	31	VIc-1	34	Loam Bottom	38
Gt	Guest clay loam	18	IIIs-8	33	VIs-1	34	Clay Bottom	37
Gu	Guest clay	18	IIIs-3	32	VIs-1	34	Clay Bottom	37
Ka	Karro loam	19	IIs-7	32	VIs-1	34	Limy Upland	39
KbE	Kimbrough gravelly loam, 2 to 25 percent slopes	19	------	--	VIs-1	34	Limy Upland	39
KhE	Kimbrough very cobbly loam, shallow over bedrock variant, 15 to 30 percent slopes	20	------	--	VIIs-1	34	Limy Upland	39
LuD	Luzena gravelly clay loam, 5 to 15 percent slopes	20	------	--	VIe-1	34	Loamy Upland	39
LvE	Luzena very cobbly loam, very cobbly subsoil variant, 15 to 30 percent slopes	21	------	--	VIIs-1	34	Loamy Hills	39
Mc	McAllister loam	22	I-1	31	VIc-1	34	Loamy Upland	39
Mk	McAllister loam, alkali	22	IIIs-9	33	VIIs-1	34	Loamy Upland	39
Pm	Pima loam	23	I-1	31	VIc-1	34	Loam Bottom	38
Pr	Pridham loam	23	IVw-9	33	VIw-1	34	Seepland	37
SnA	Sonoita sandy loam, 0 to 2 percent slopes	24	IIs-7	32	VIs-1	34	Sand Upland	38
SnB	Sonoita sandy loam, 2 to 5 percent slopes	24	IIe-7	31	VIe-1	34	Sand Upland	38
SoA	Sonoita gravelly sandy loam, 0 to 2 percent slopes	25	IIIs-7	32	VIs-1	34	Sand Upland	38
St	Stewart loam	26	------	--	VIIs-1	34	Saline Bottom	36
To	Torrifluvents	26	------	--	VIIw-1	34	Loam Bottom	38
TrC	Torriorthents, hummocky	26	------	--	VIIe-1	34	Hummock Upland	38

Map symbol	Mapping unit	Described on page	Capability unit: Irrigated Symbol	Irrigated Page	Dryland Symbol	Dryland Page	Range site Name	Range site Page
TuA	Tubac sandy loam, 0 to 2 percent slopes---	27	IIIs-8	33	VIs-1	34	Loamy Upland	39
TvD	Tubac gravelly loam, 10 to 20 percent slopes-----------------------------------	27	------	--	VIe-1	34	Loamy Hills	39
TwA	Tubac sandy clay loam, 0 to 2 percent slopes-----------------------------------	28	IIIs-8	33	VIs-1	34	Loamy Upland	39
Vn	Vinton loamy sand-------------------------	28	------	--	VIe-1	34	Sand Upland	38

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ARIZONA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

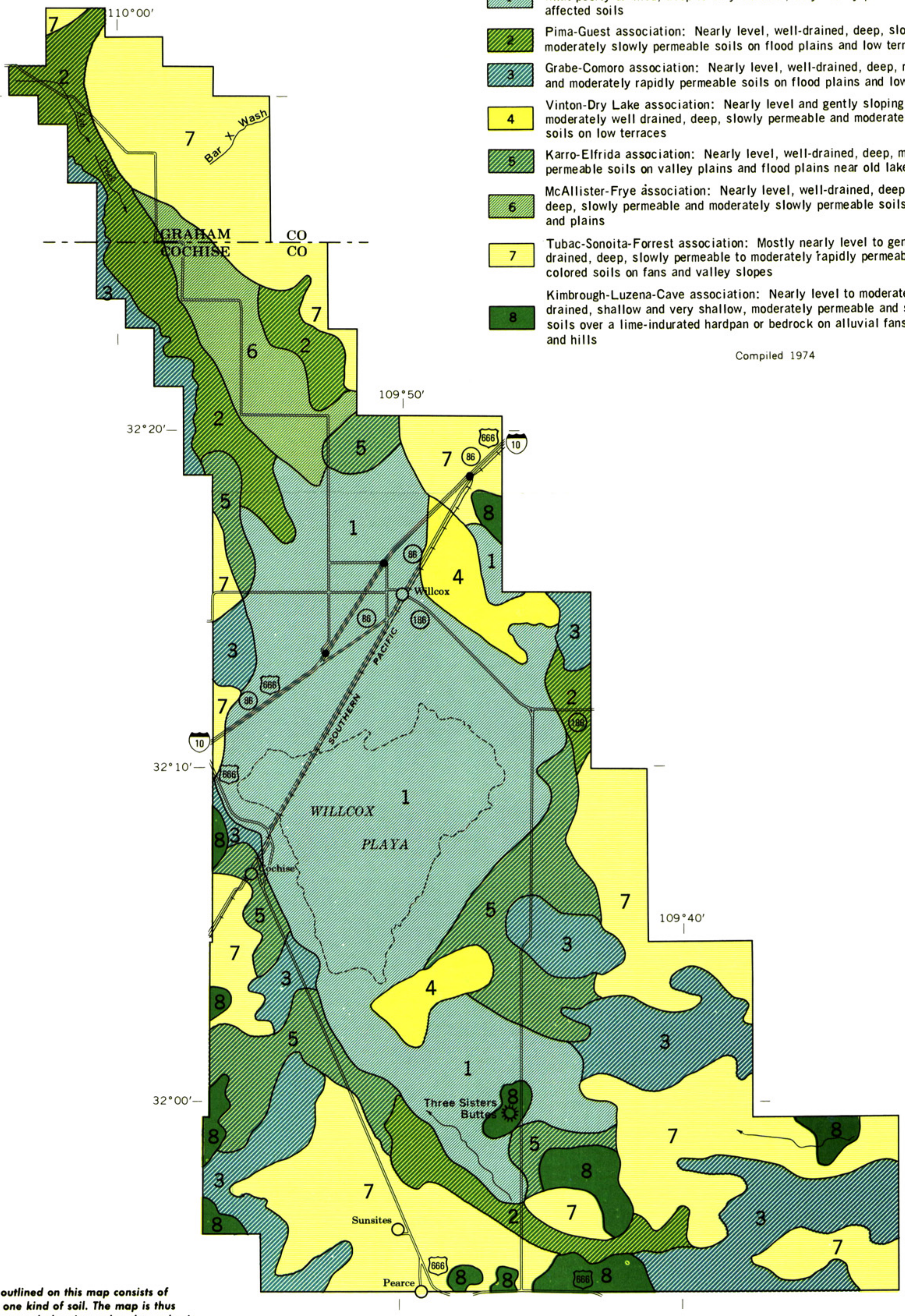
WILLCOX AREA, ARIZONA

PARTS OF COCHISE AND GRAHAM COUNTIES

Scale 1:253,440

1 0 1 2 3 4 Miles

N



SOIL ASSOCIATIONS

1. Gothard-Crot-Stewart association: Nearly level, moderately well drained and somewhat poorly drained, deep to very shallow, very slowly permeable, saline-alkali affected soils
2. Pima-Guest association: Nearly level, well-drained, deep, slowly permeable and moderately slowly permeable soils on flood plains and low terraces
3. Grabe-Comoro association: Nearly level, well-drained, deep, moderately permeable and moderately rapidly permeable soils on flood plains and low terraces
4. Vinton-Dry Lake association: Nearly level and gently sloping, well drained and moderately well drained, deep, slowly permeable and moderately rapidly permeable soils on low terraces
5. Karro-Elfrida association: Nearly level, well-drained, deep, moderately slowly permeable soils on valley plains and flood plains near old lake margins
6. McAllister-Frye association: Nearly level, well-drained, deep and moderately deep, slowly permeable and moderately slowly permeable soils on valley slopes and plains
7. Tubac-Sonoita-Forrest association: Mostly nearly level to gently sloping, well-drained, deep, slowly permeable to moderately rapidly permeable, mainly reddish-colored soils on fans and valley slopes
8. Kimbrough-Luzena-Cave association: Nearly level to moderately steep, well-drained, shallow and very shallow, moderately permeable and slowly permeable soils over a lime-indurated hardpan or bedrock on alluvial fans, valley plains, and hills

Compiled 1974

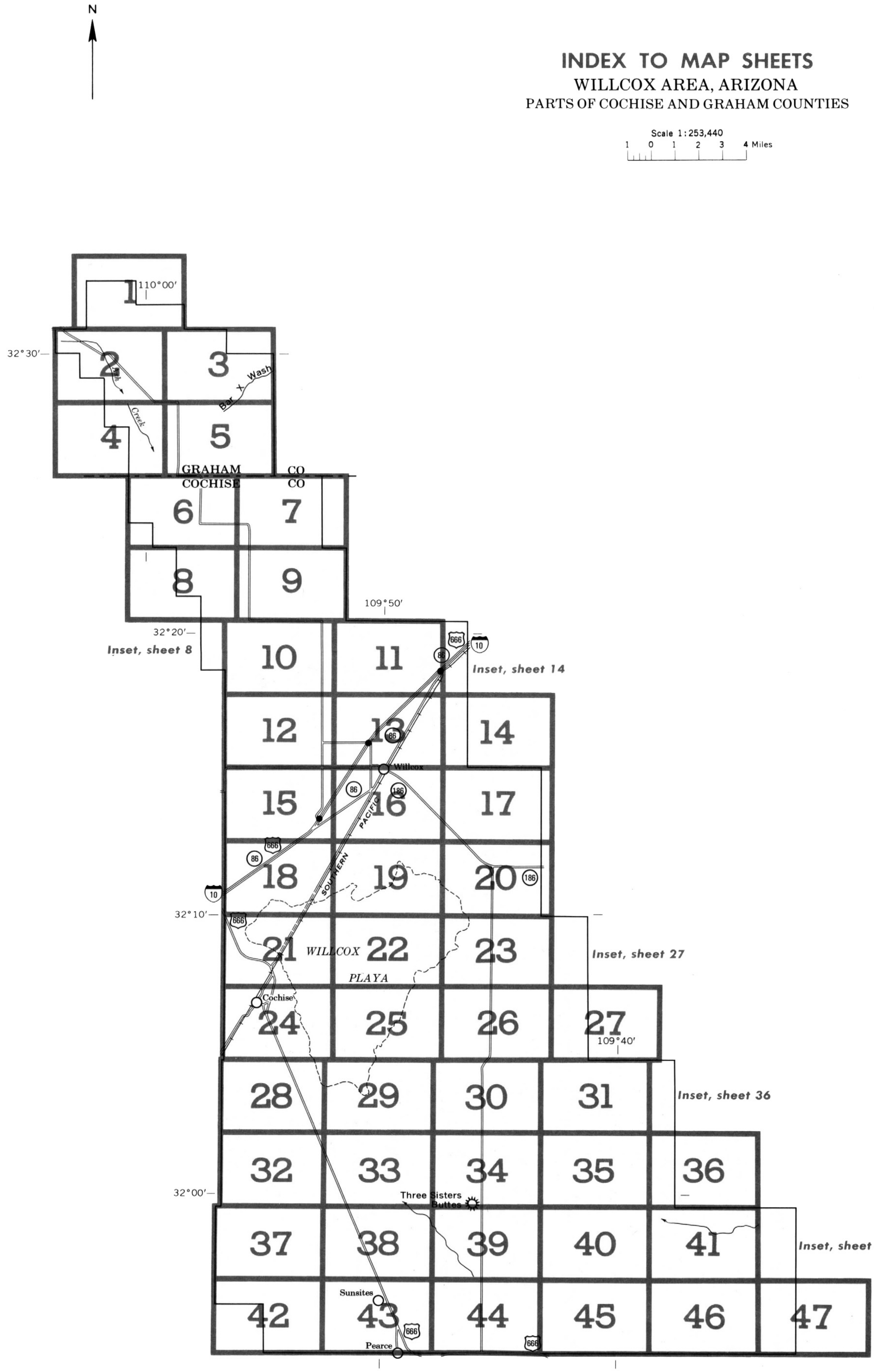
Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

INDEX TO MAP SHEETS

WILLCOX AREA, ARIZONA

PARTS OF COCHISE AND GRAHAM COUNTIES

Scale 1:253,440



SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, or E indicates the class of slope. Most symbols without a slope letter are those of nearly level soils, but a few are for soils that have steeper slopes in some areas.

SYMBOL	NAME
BeC	Bernardino complex, 0 to 10 percent slopes
Ca	Cave gravelly loam
Cc	Cogswell clay loam
Ce	Cogswell clay loam, alkali
Cg	Cogswell clay
CmA	Comoro sandy loam, 0 to 2 percent slopes
CnA	Comoro gravelly sandy loam, 0 to 2 percent slopes
CnC	Comoro gravelly sandy loam, 5 to 10 percent slopes
Co	Comoro sandy loam, alkali variant
Cs	Cowan sandy loam
Ct	Crot sandy loam
Dr	Dry Lake loamy sand
Du	Duncan loam
Dv	Duncan loam, shallow variant
Ef	Elfrida silty clay loam
FoA	Forrest loam, 0 to 2 percent slopes
FrA	Forrest gravelly sandy clay loam, 0 to 2 percent slopes
FrB	Forrest gravelly sandy clay loam, 2 to 5 percent slopes
Fy	Frye sandy loam
Go	Gothard fine sandy loam
Gr	Grabe sandy loam
Gs	Grabe loam
Gt	Guest clay loam
Gu	Guest clay
Ka	Karro loam
KbE	Kimbrough gravelly loam, 2 to 25 percent slopes
KhE	Kimbrough very cobbly loam, shallow over bedrock variant, 15 to 30 percent slopes
LuD	Luzena gravelly clay loam, 5 to 15 percent slopes
LvE	Luzena very cobbly loam, very cobbly subsoil variant, 15 to 30 percent slopes
Mc	McAllister loam
Mk	McAllister loam, alkali
Pm	Pima loam
Pr	Pridham loam
SnA	Sonoita sandy loam, 0 to 2 percent slopes
SnB	Sonoita sandy loam, 2 to 5 percent slopes
SoA	Sonoita gravelly sandy loam, 0 to 2 percent slopes
St	Stewart loam
To	Torrifluvents
TrC	Torriorthents, hummocky
TuA	Tubac sandy loam, 0 to 2 percent slopes
TvD	Tubac gravelly loam, 10 to 20 percent slopes
TwA	Tubac sandy clay loam, 0 to 2 percent slopes
Vn	Vinton loamy sand

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Divided
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail
- Railroad
- Ferry (FY)
- Ford (FORD)
- Grade
- R. R. over
- R. R. under

Buildings
- School
- Church

Mine and quarry

Gravel pit (G.P.)

Power line

Pipeline

Cemetery

Dams

Levee

Airway beacon

Cotton gin

Water trough

Windmill

Located object

BOUNDARIES

- National or state
- County
- Minor civil division
- Reservation
- Soil survey
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Unclassified

Canals and ditches

Lakes and ponds
- Perennial (water, w)
- Intermittent (int)

Spring

Well, irrigation

Wet spot

Drainage end or alluvial fan

RELIEF

Escarpments
- Bedrock
- Other

Short steep slope

Prominent peak

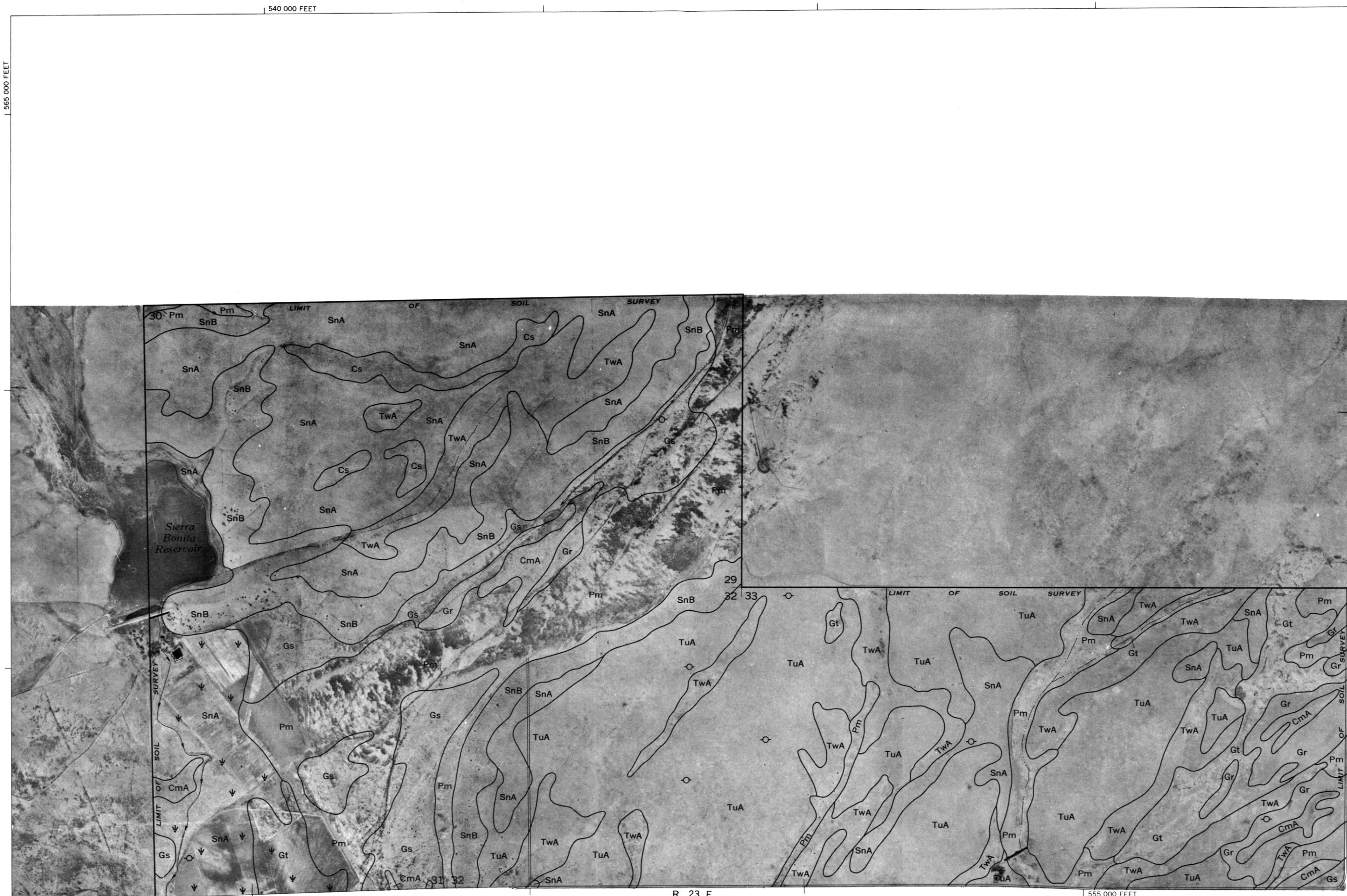
Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stoniness
  - Stony
  - Very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully
- Borrow pit (B.P.)
- Cut and fill land (C.F.L.)
- Sand pit (S.P.)
- Saline or alkali spot
- Soil sample site

1

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.
Land Division corners are approximately positioned on this map.

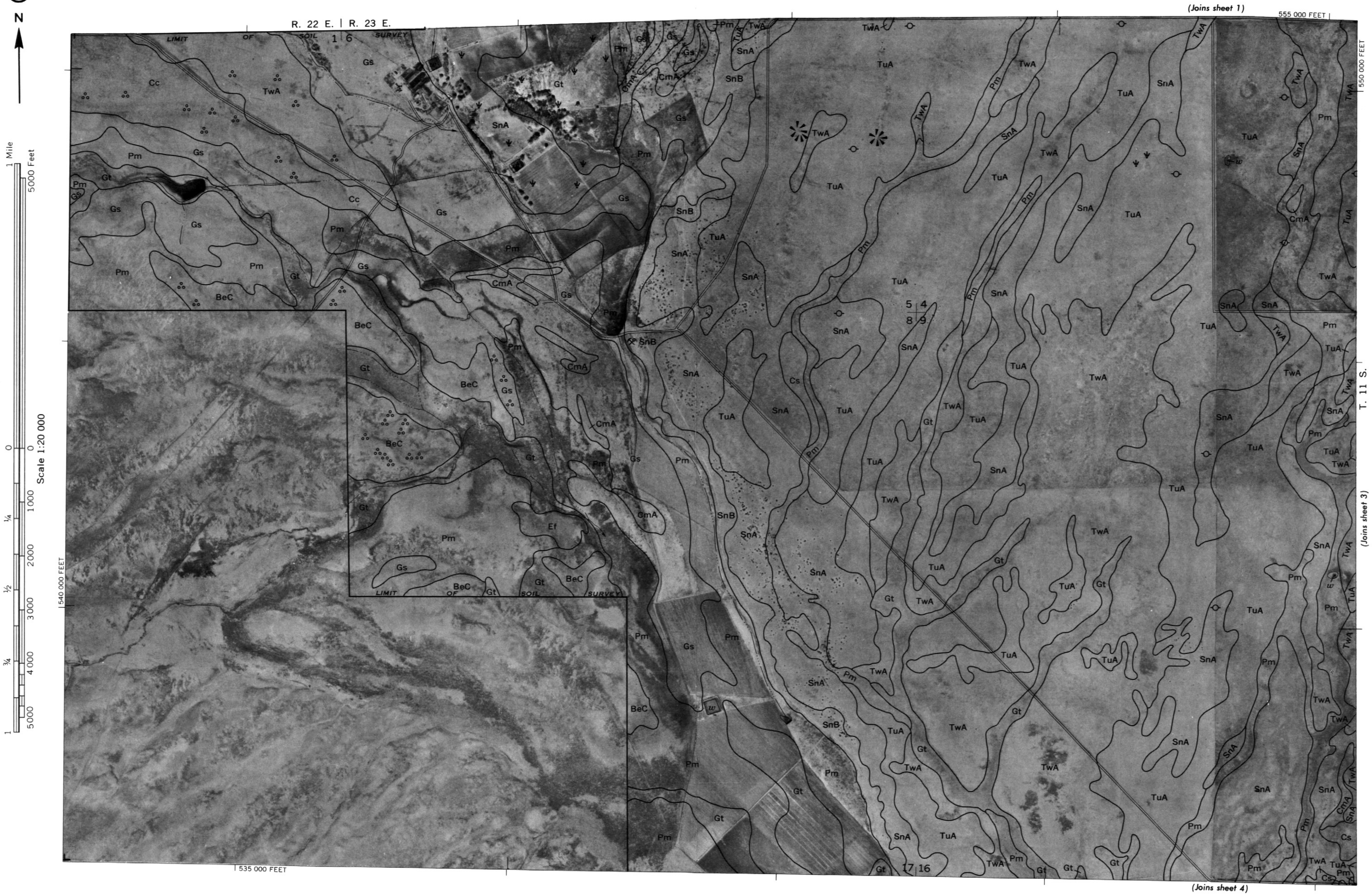


N

1 Mile
5000 Feet
Scale 1:20 000
0 ¼ ½ ¾ 1
0 1000 2000 3000 4000 5000

(Joins sheet 2) | (Joins sheet 3)

WILLCOX AREA, ARIZONA — SHEET NUMBER 2



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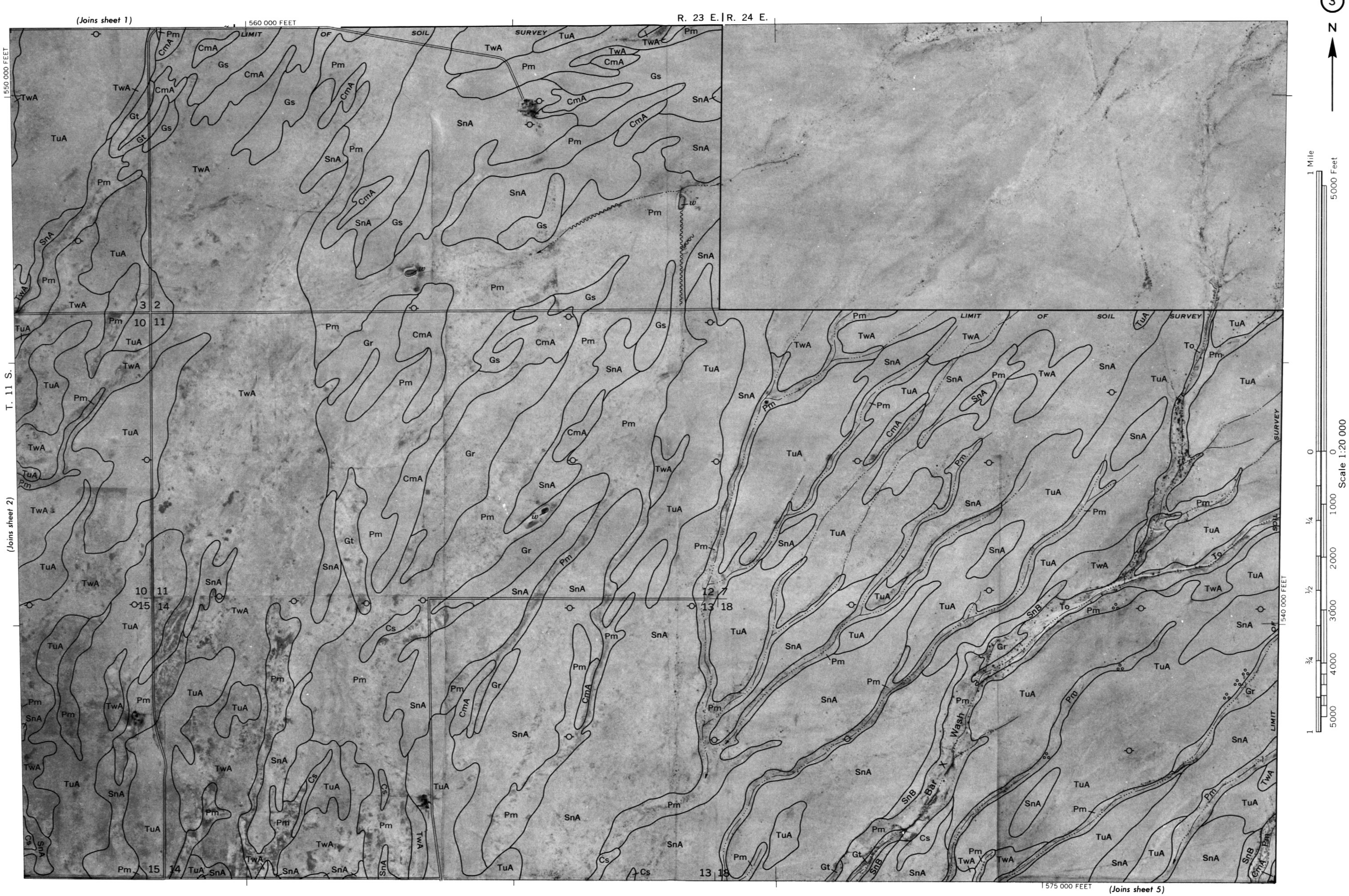

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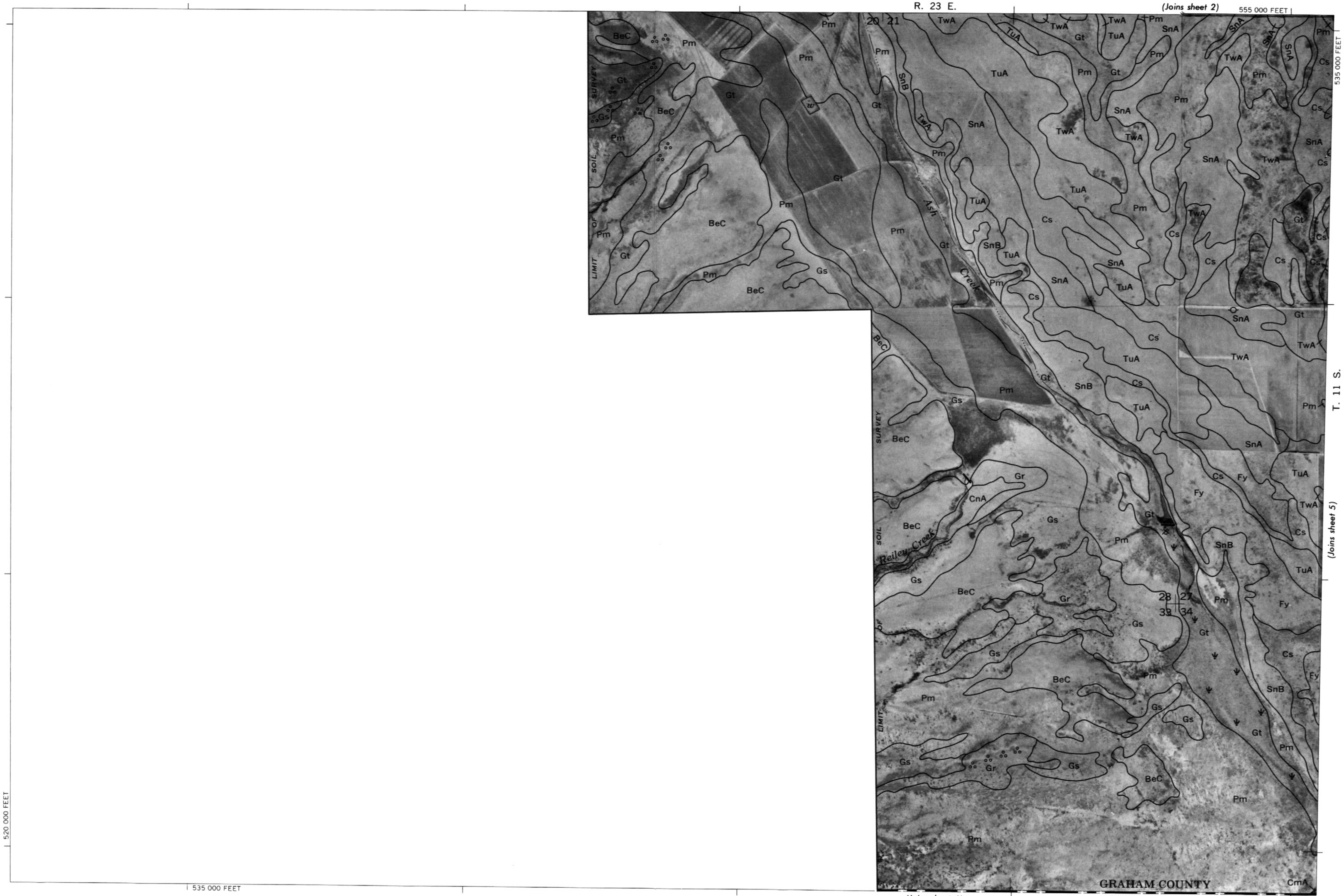
WILLCOX AREA, ARIZONA — SHEET NUMBER 4

N

Scale 1:20 000

0 ¼ ½ ¾ 1 Mile

0 1000 2000 3000 4000 5000 Feet



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5

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Land Division corners are approximately positioned on this map.

WILLCOX AREA, ARIZONA NO. 5

N

1 Mile
5000 Feet
0
¼
½
¾
1
0
1000
2000
3000
4000
5000
Scale 1:20 000

6

N

1 Mile
5000 Feet
Scale 1:20 000
0 1000 2000 3000 4000 5000
0 ¼ ½ ¾ 1

Land Division corners are approximately positioned on this map.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.
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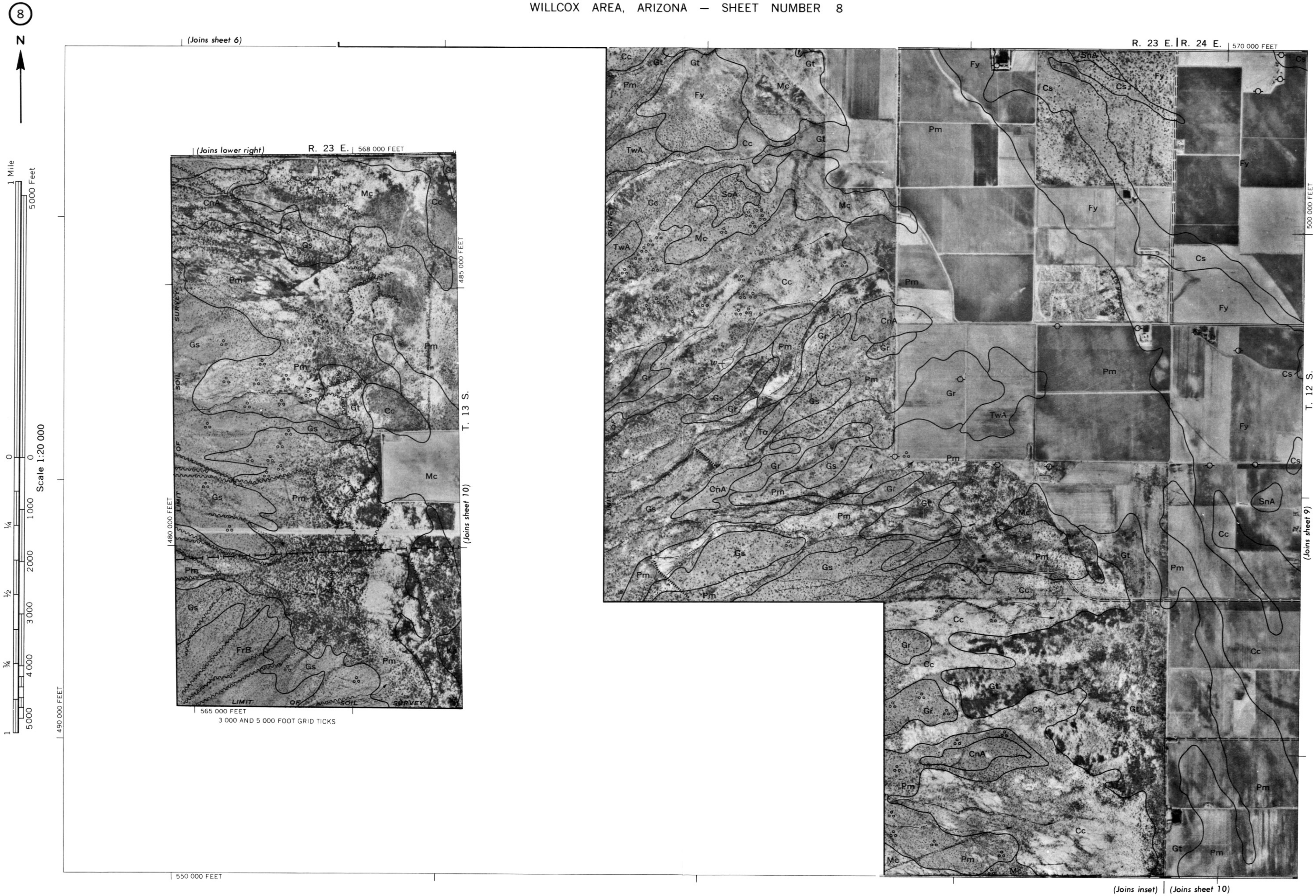
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.
Land Division corners are approximately positioned on this map.

WILLCOX AREA, ARIZONA NO. 7



Land Division corners are approximately positioned on this map.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone, 1927 North American datum.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.

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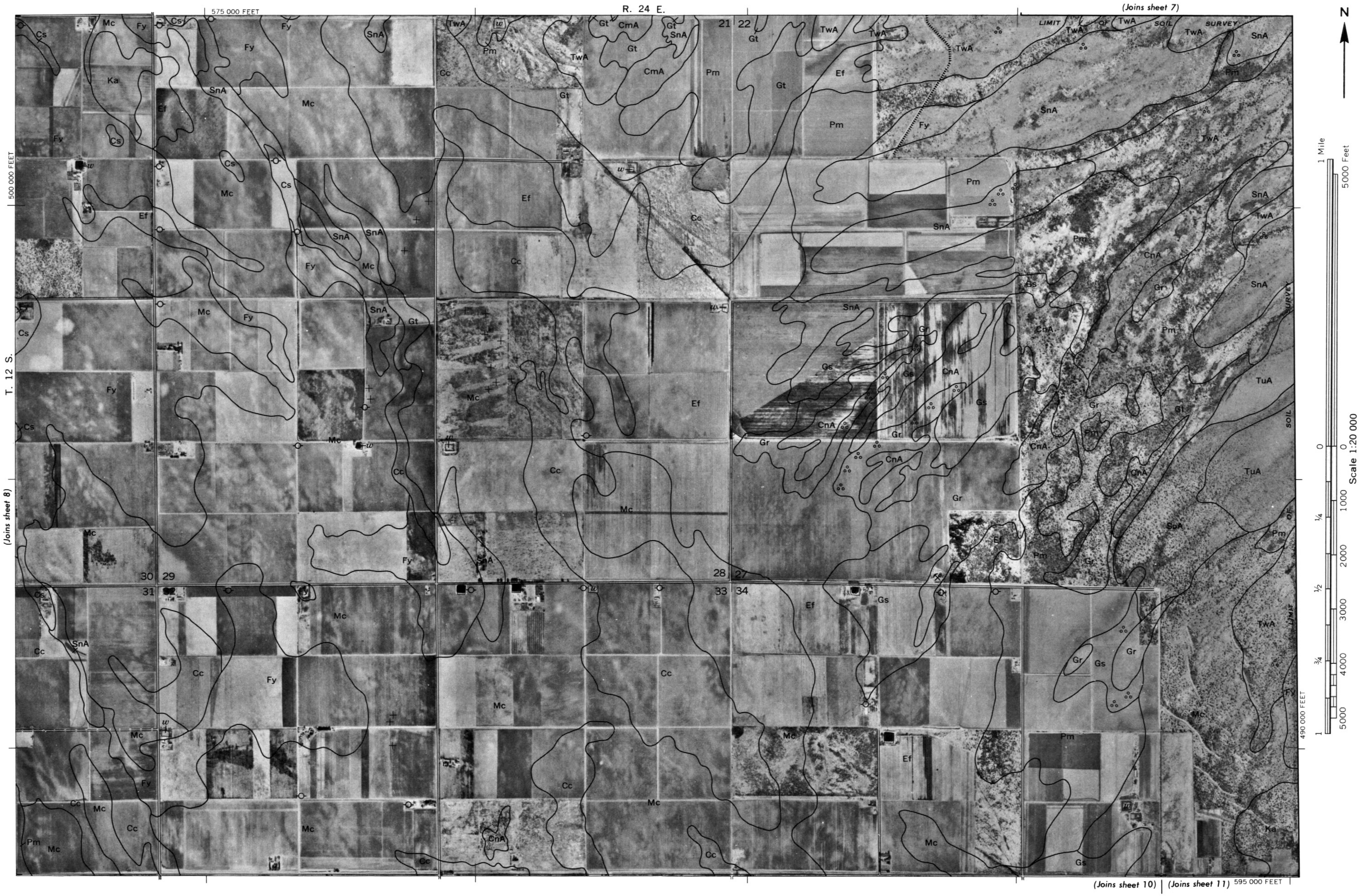
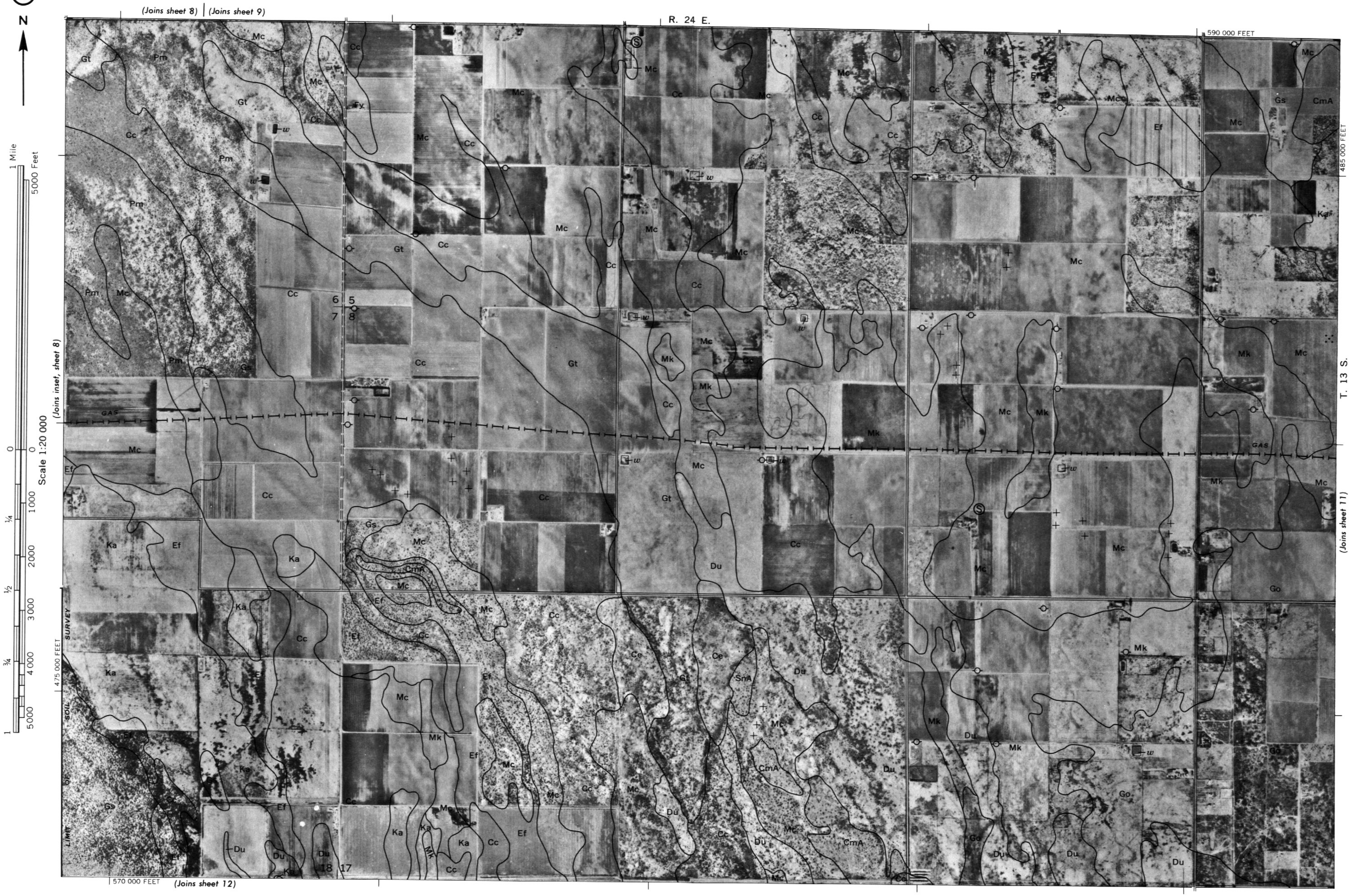
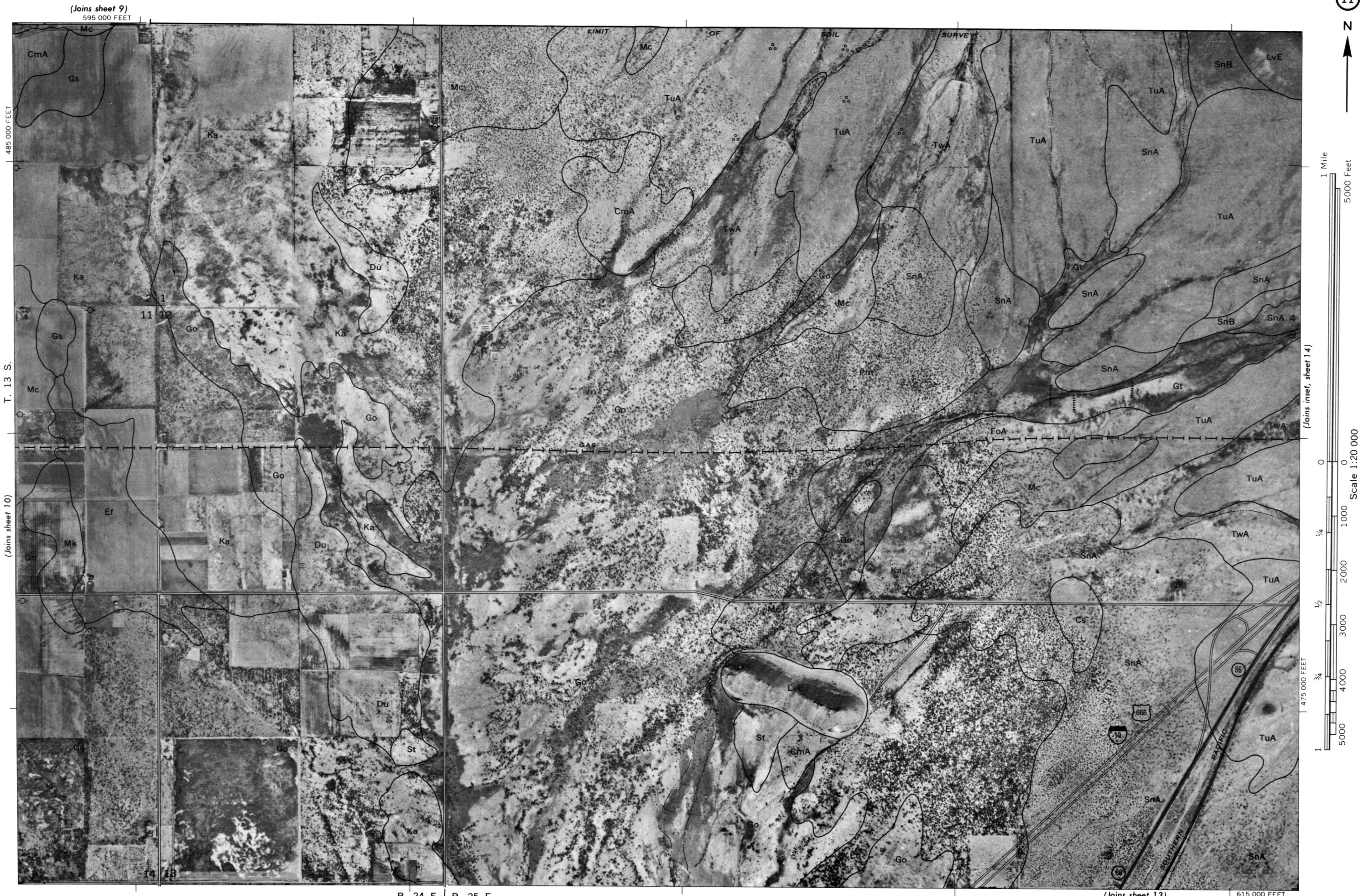




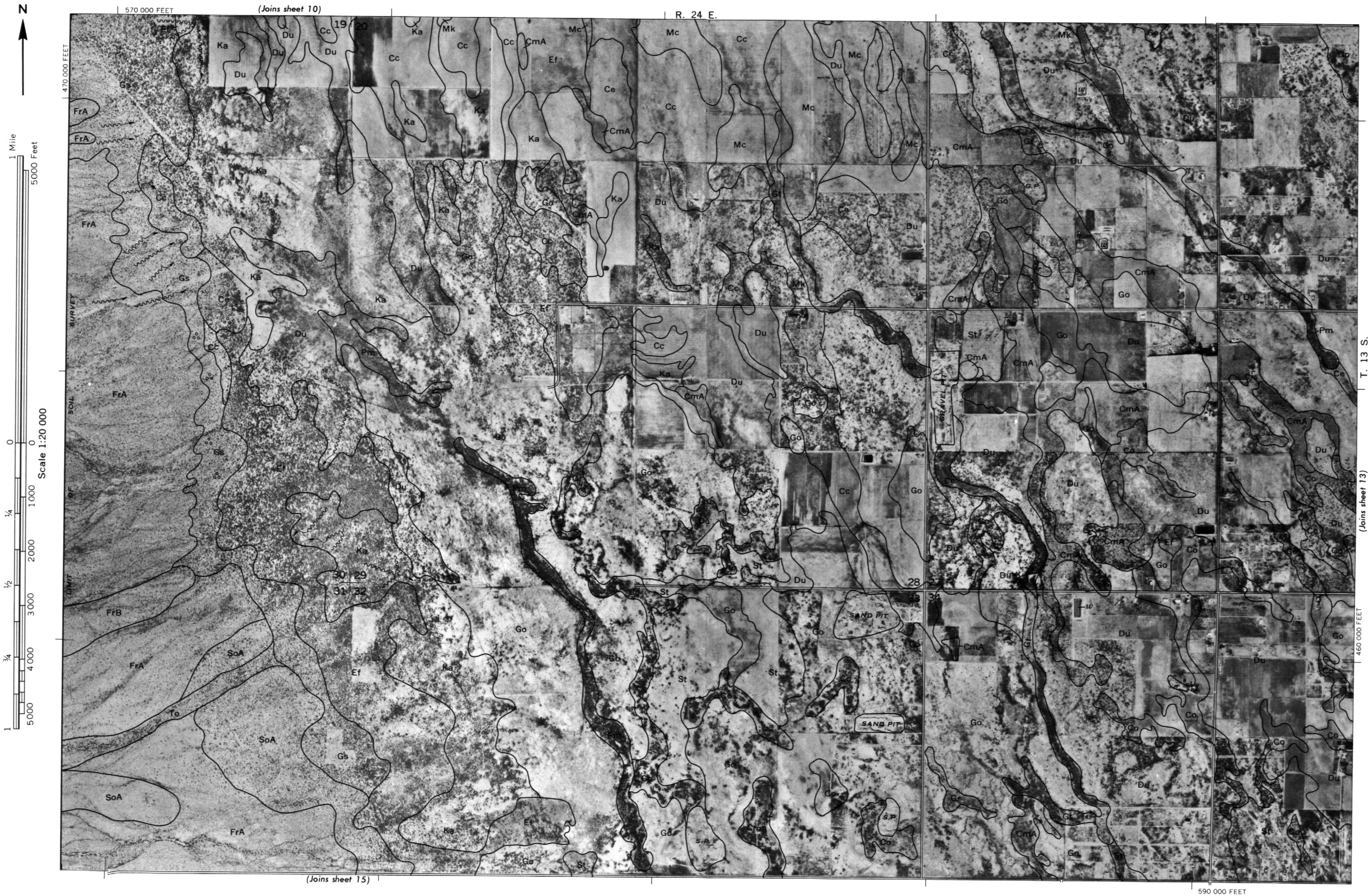
Land Division corners are approximately positioned on this map.

Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone, 1927 North American datum.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.
Land Division corners are approximately positioned on this map.



Land Division corners are approximately positioned on this map.

Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.

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13

595 000 FEET

(Joins sheet 11)

N

470 000 FEET

T. 13 S.

(Joins sheet 12)

(Joins sheet 14)

460 000 FEET

1 Mile

5000 Feet

Scale 1:20 000

0 ¼ ½ ¾ 1

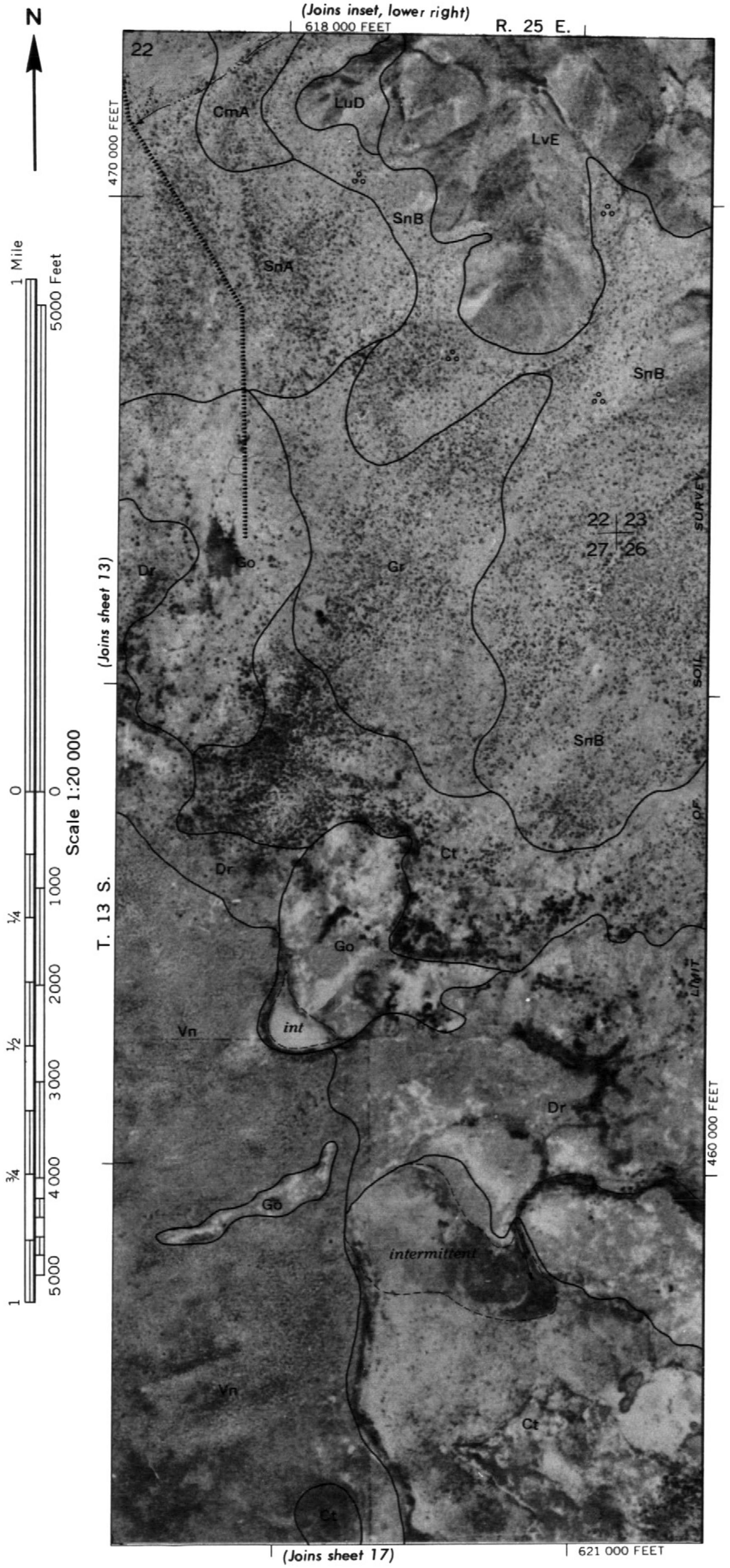
0 1000 2000 3000 4000 5000

R. 24 E. | R. 25 E.

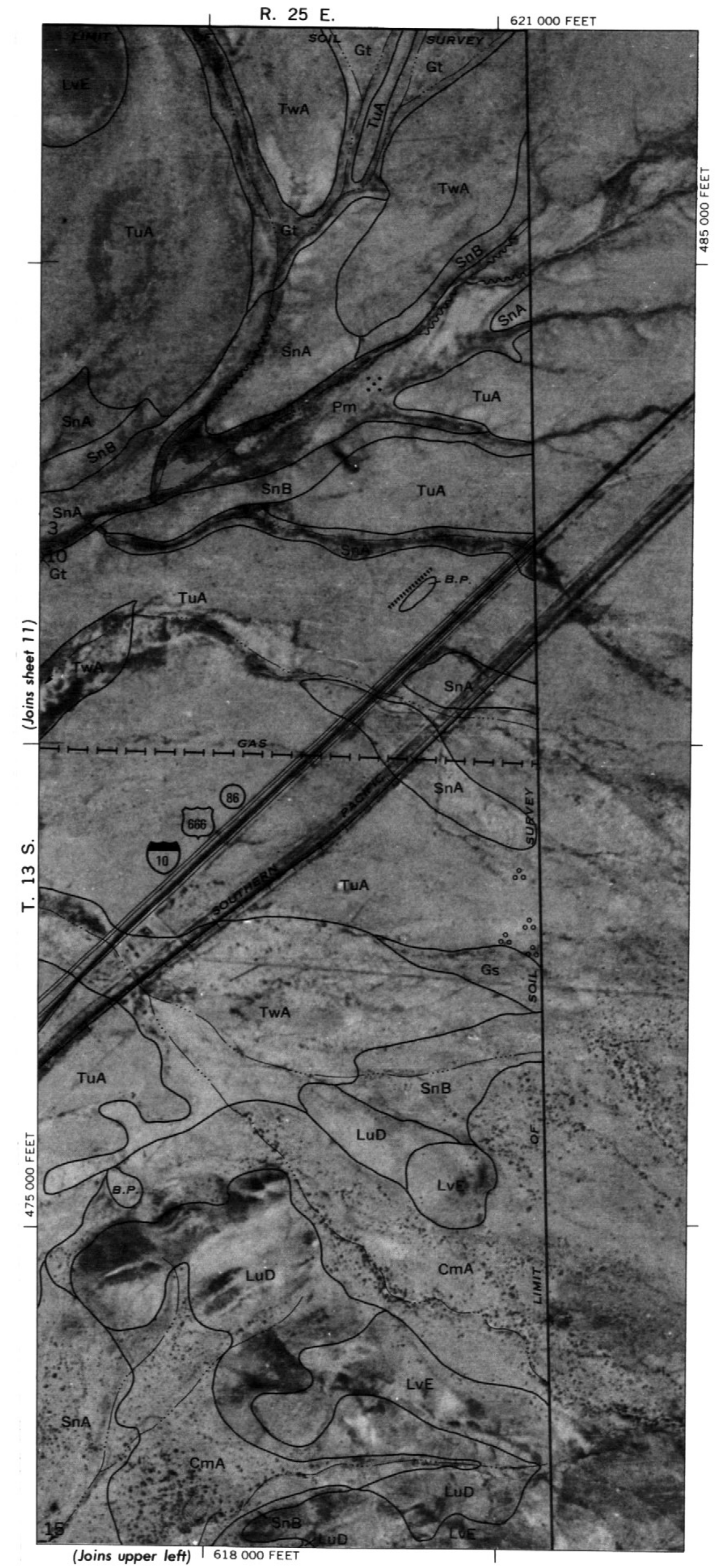
(Joins sheet 16)

615 000 FEET

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station. Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum. Land Division corners are approximately positioned on this map.



3 000 AND 5 000 FOOT GRID TICKS



3 000 AND 5 000 FOOT GRID TICKS

Land Division corners are approximately positioned on this map.

Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone, 1927 North American datum.

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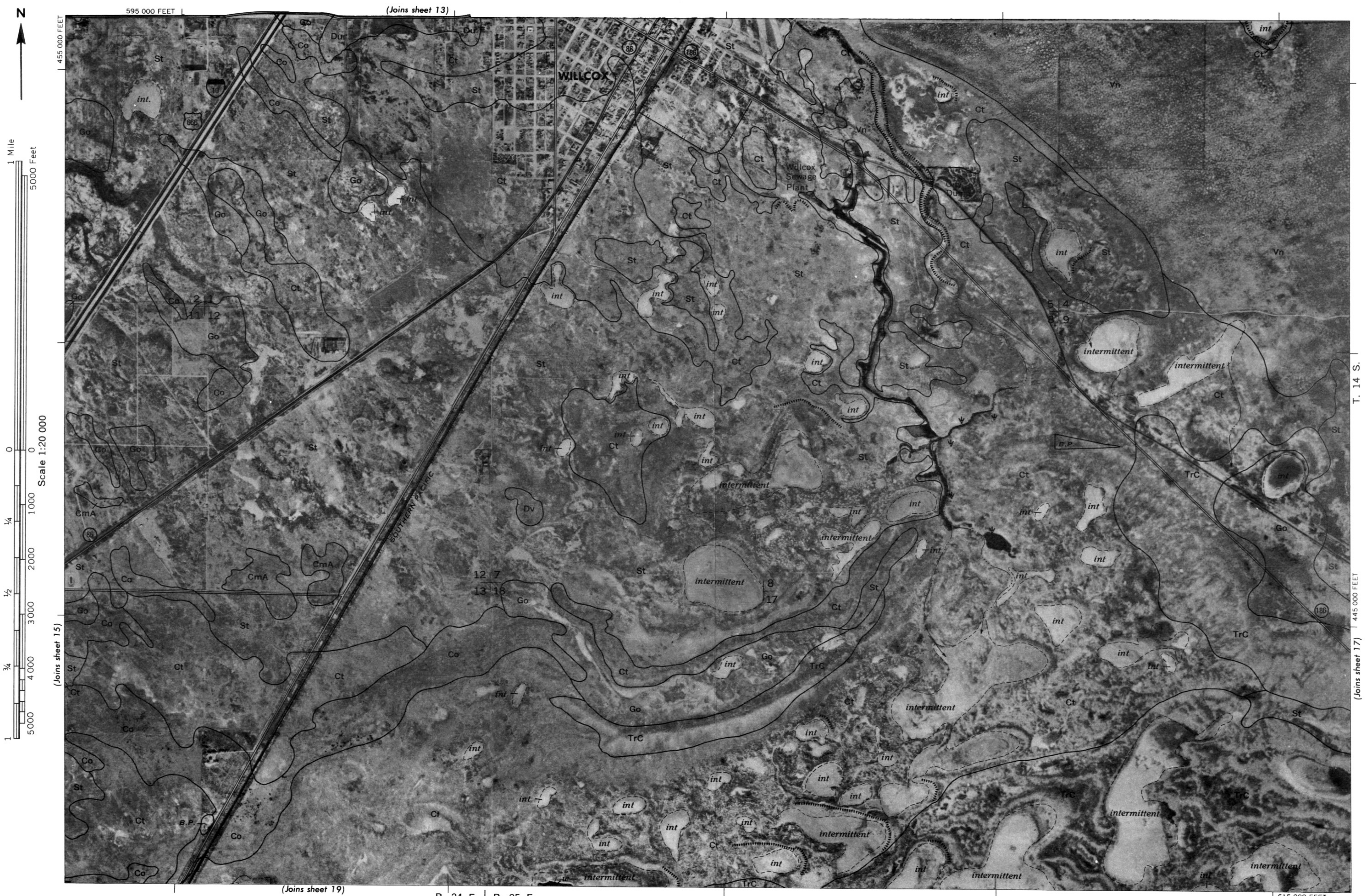
Land Division corners are approximately positioned on this map.



Land Division corners are approximately positioned on this map.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.
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Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.

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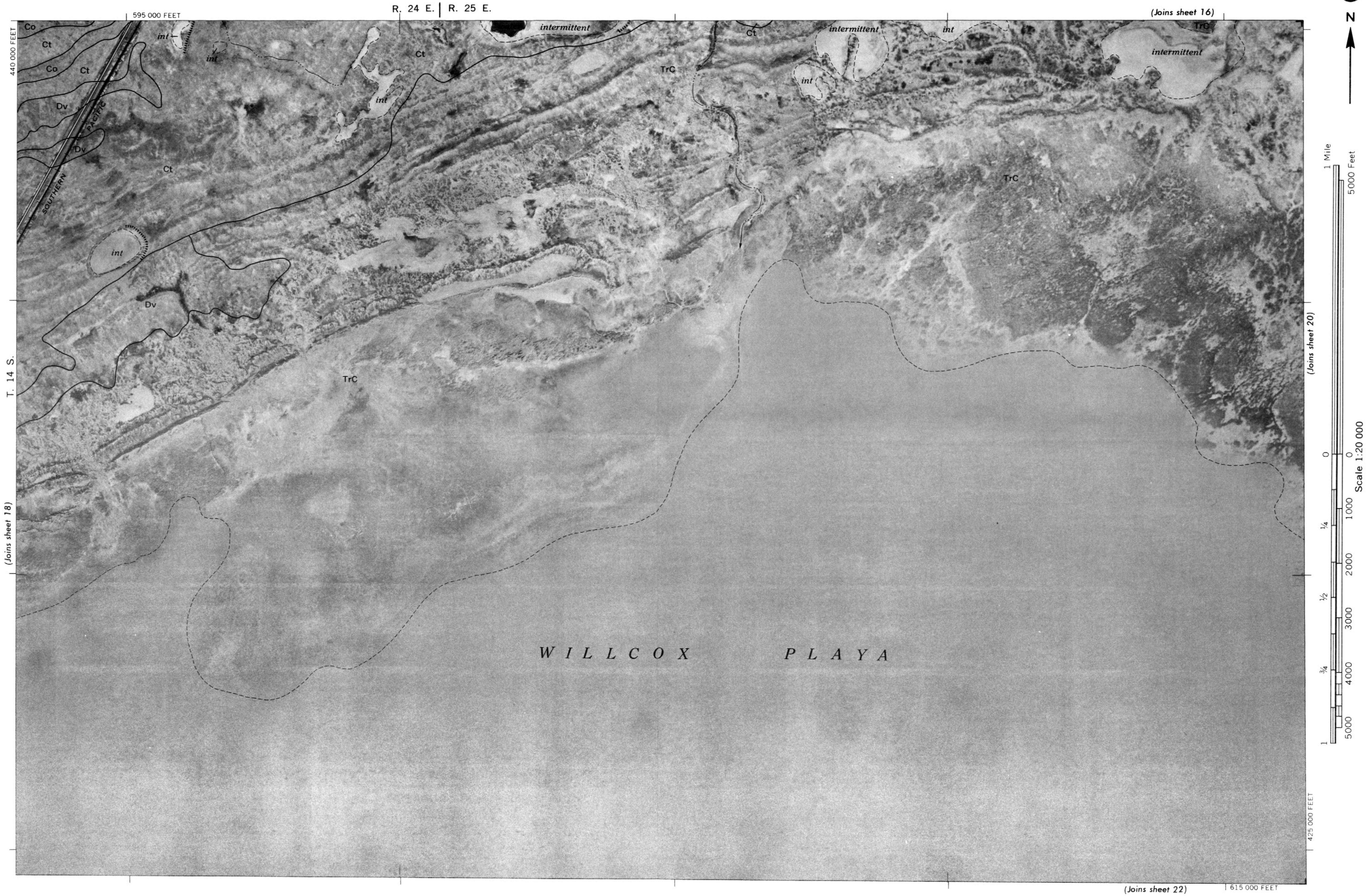
19



This map is one of a set compiled in ... by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum.
Land Division corners are approximately positioned on this map.

WILLCOX AREA, ARIZONA — SHEET NUMBER 20

N

1 Mile
5000 Feet
Scale 1:20 000
0 ¼ ½ ¾ 1
0 1000 2000 3000 4000 5000

Land Division corners are approximately positioned on this map.

Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone, 1927 North American datum.

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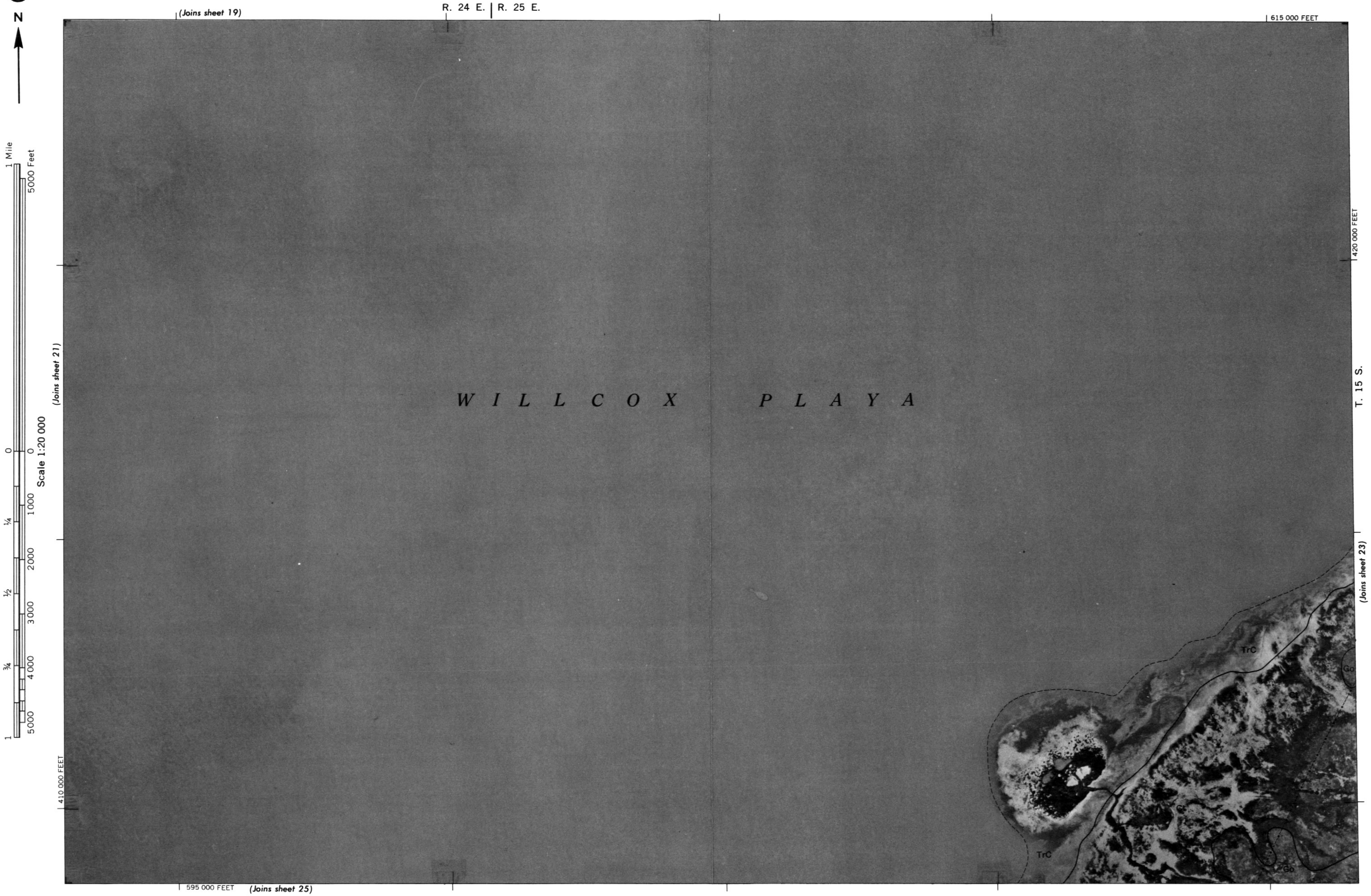
Land Division corners are approximately positioned on this map.

WILLCOX AREA, ARIZONA — SHEET NUMBER 22



Land Division corners are approximately positioned on this map.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.
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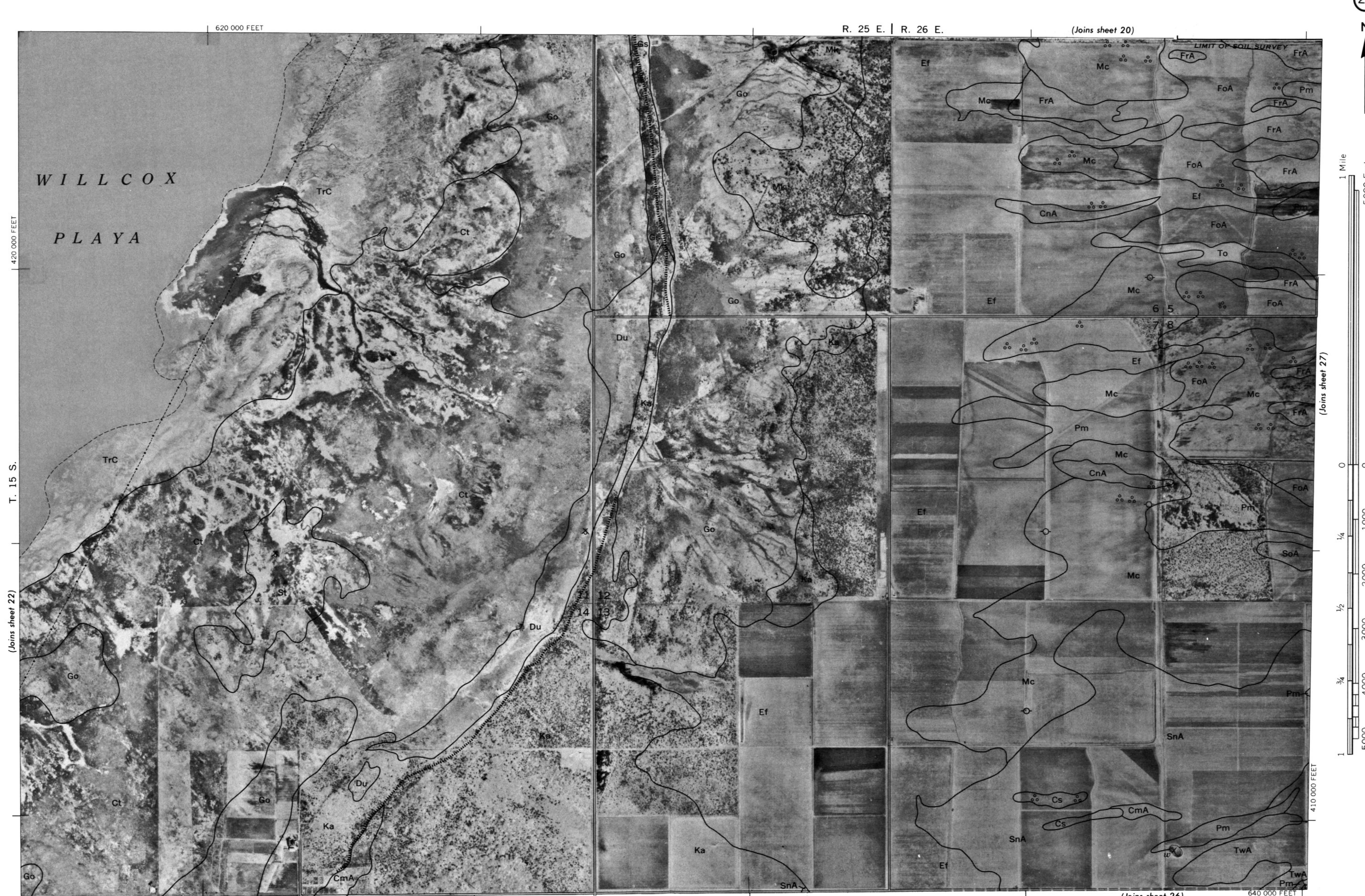
Land Division corners are approximately positioned on this map.



Land Division corners are approximately positioned on this map.

Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.

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Land Division corners are approximately positioned on this map.

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Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.
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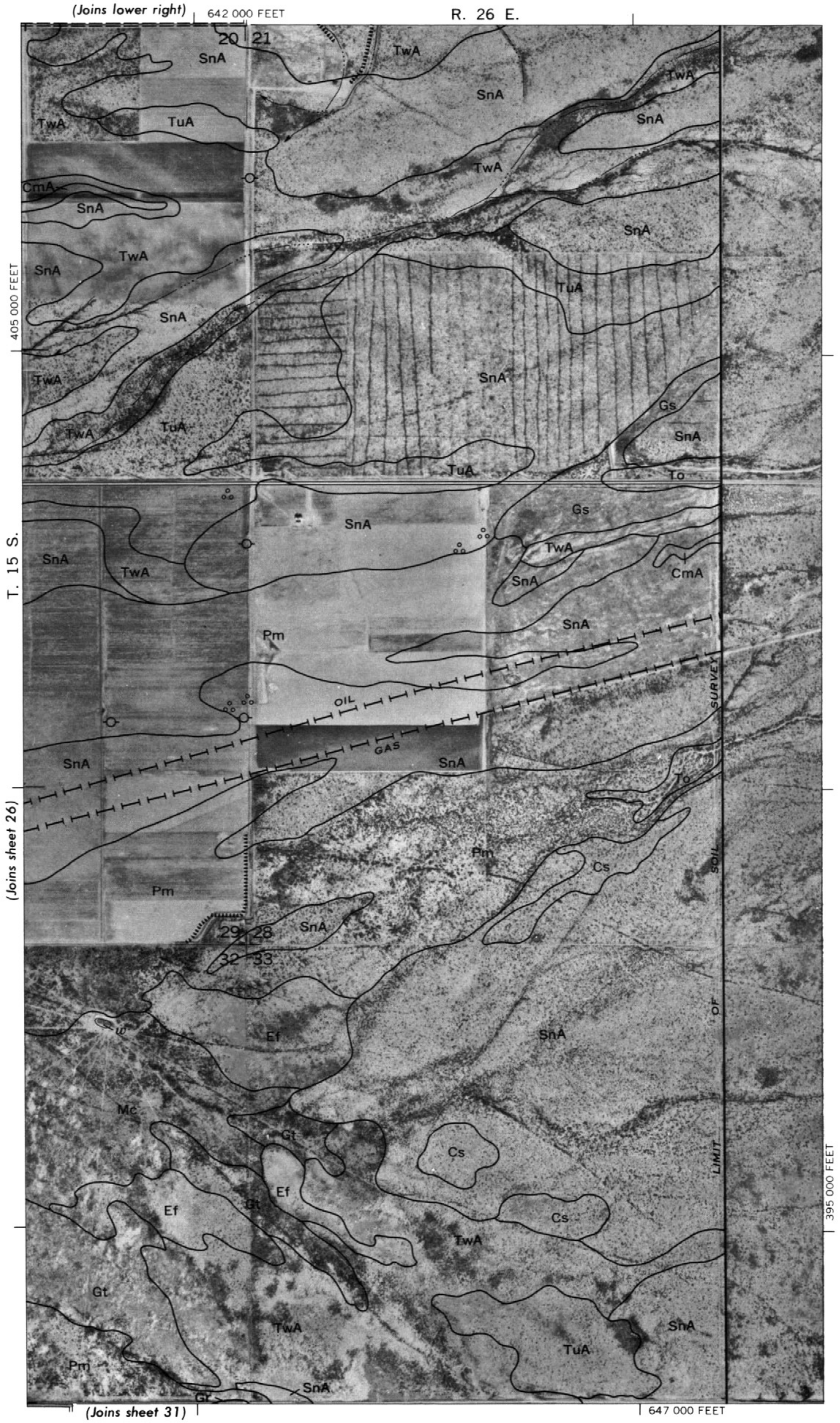
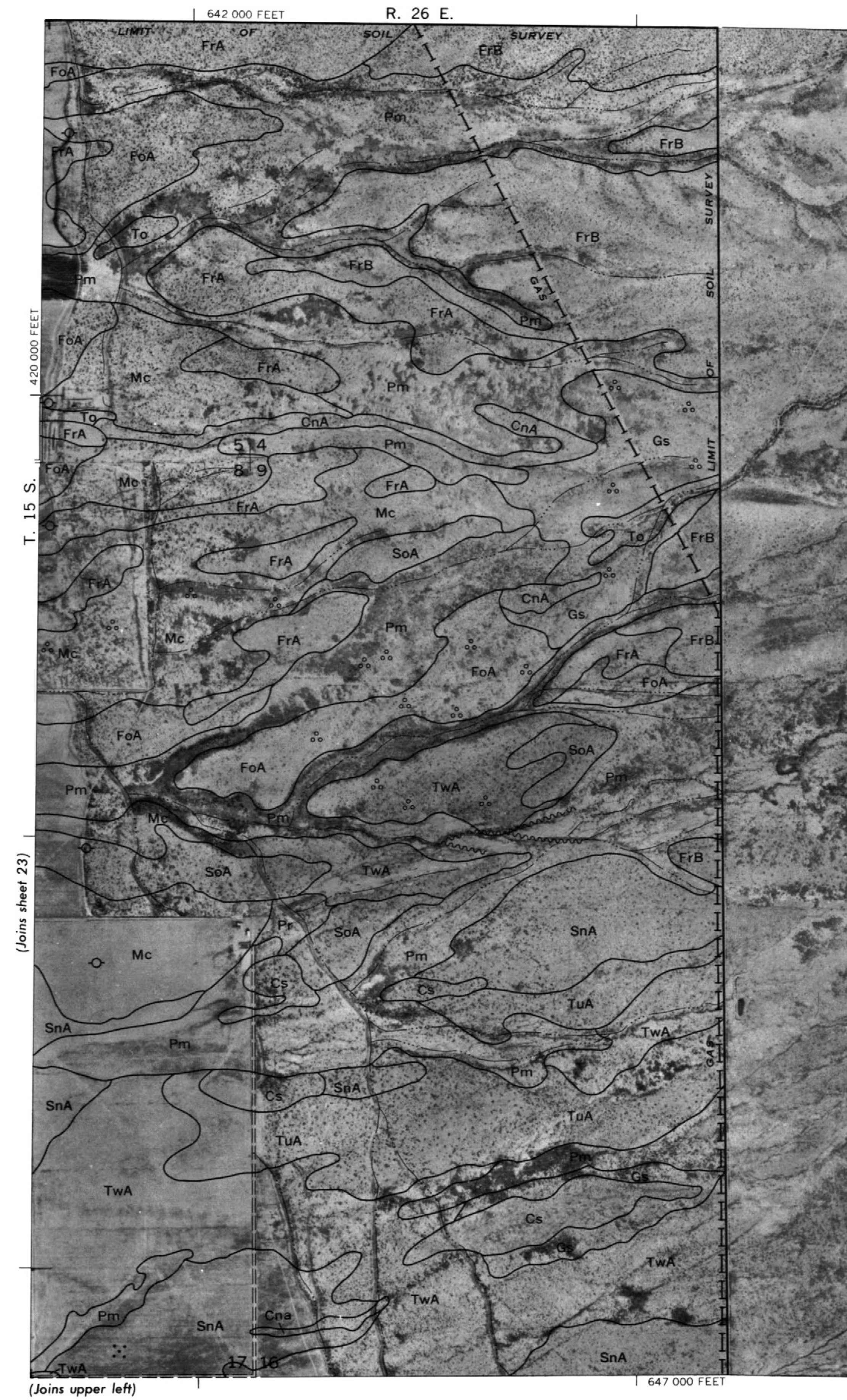
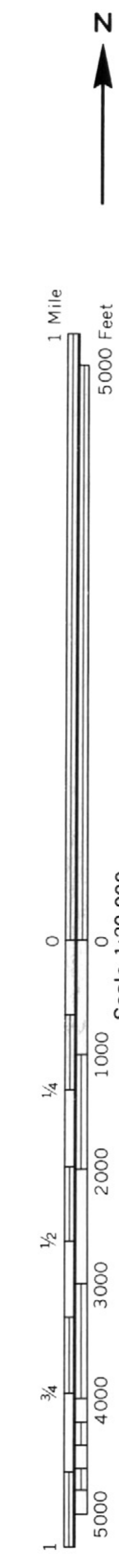
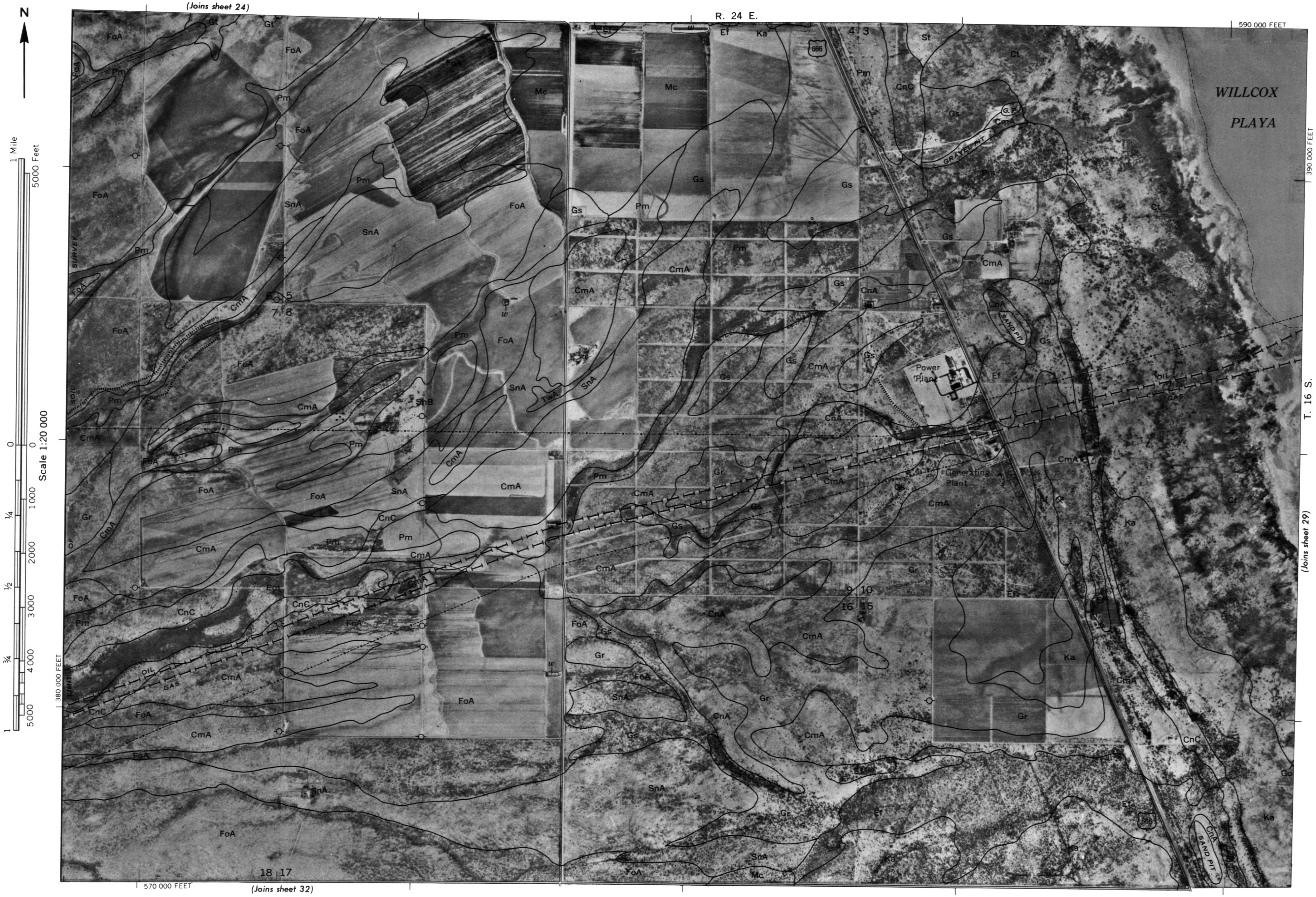
27

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum.
Land Division corners are approximately positioned on this map.









Land Division corners are approximately positioned on this map.

Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.

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29

(Joins sheet 24) | (Joins sheet 25)

N

1 Mile
5000 Feet
0
0
1/4
1000
2000
1/2
3000
3/4
4000
5000
1
Scale 1:20 000

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum.
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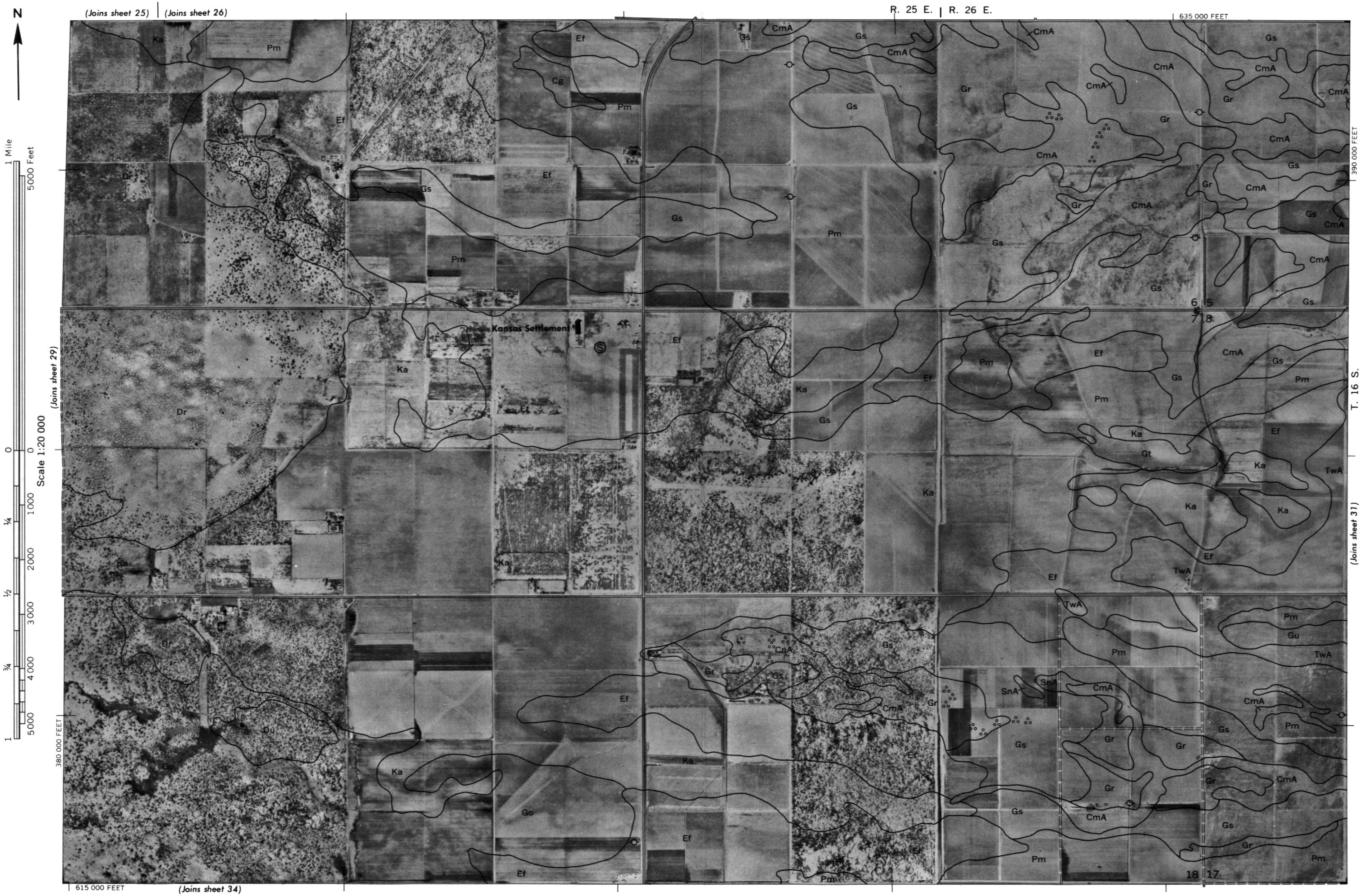

Land Division corners are approximately positioned on this map.
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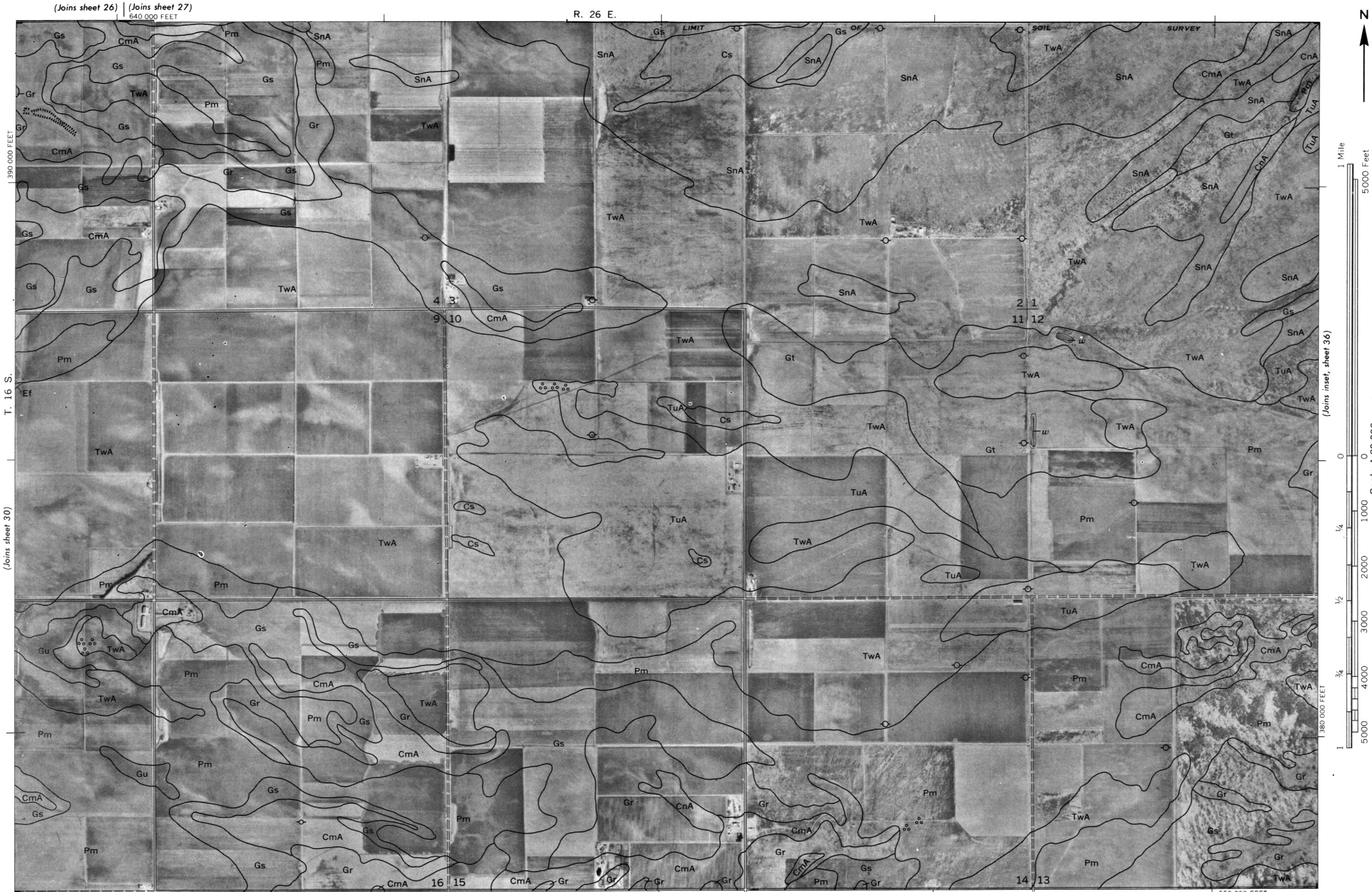
31



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.
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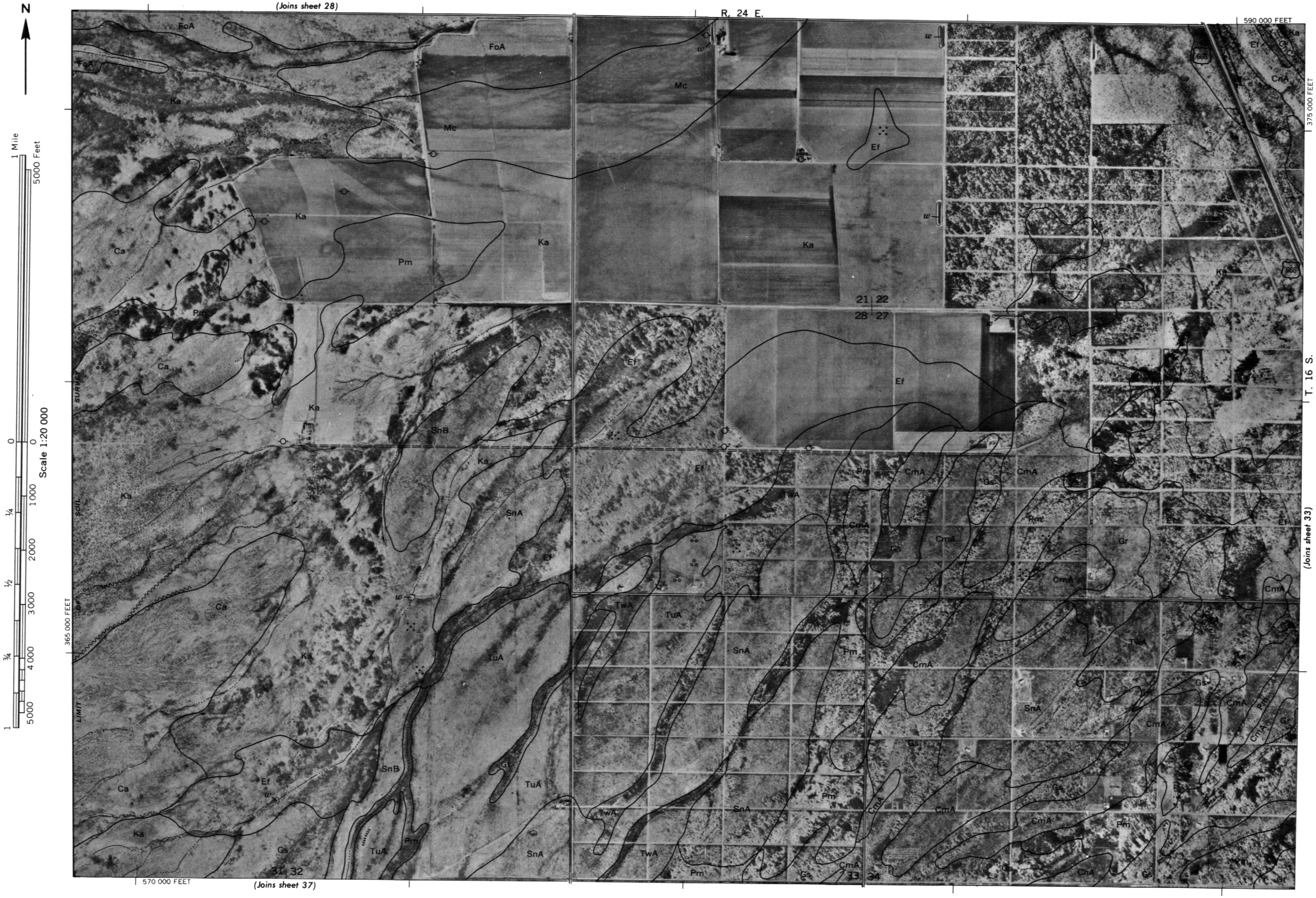

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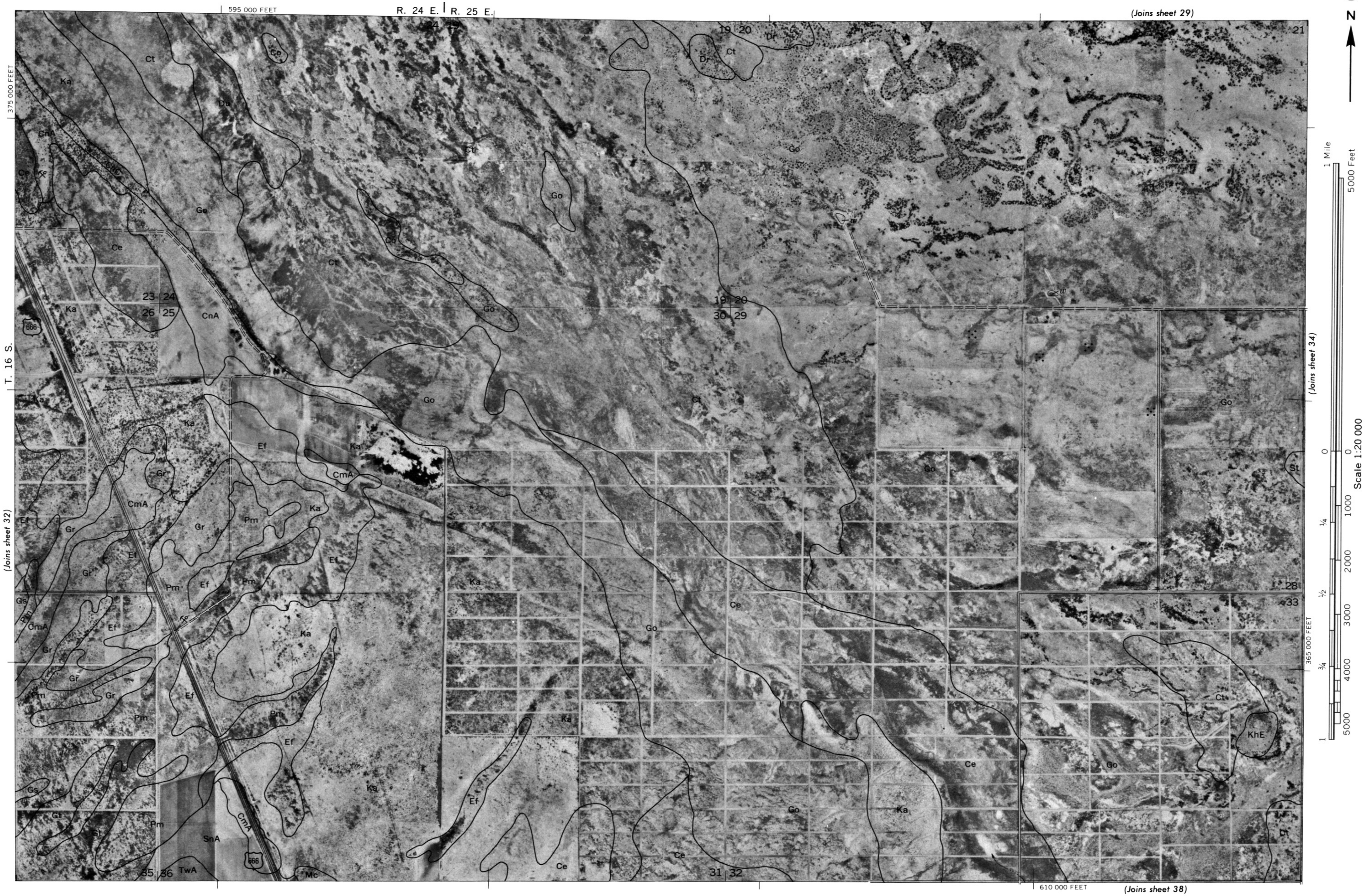

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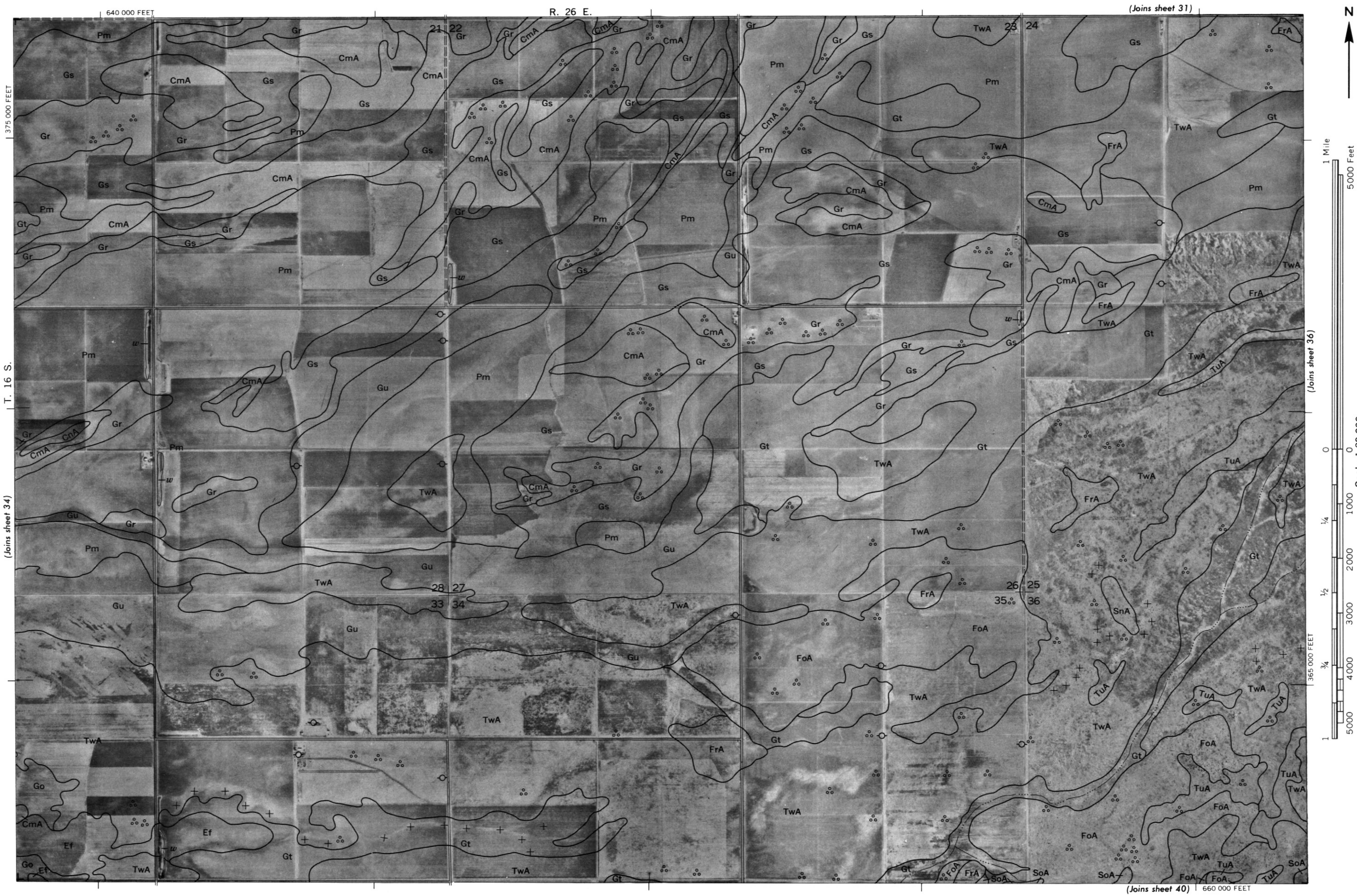

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum.
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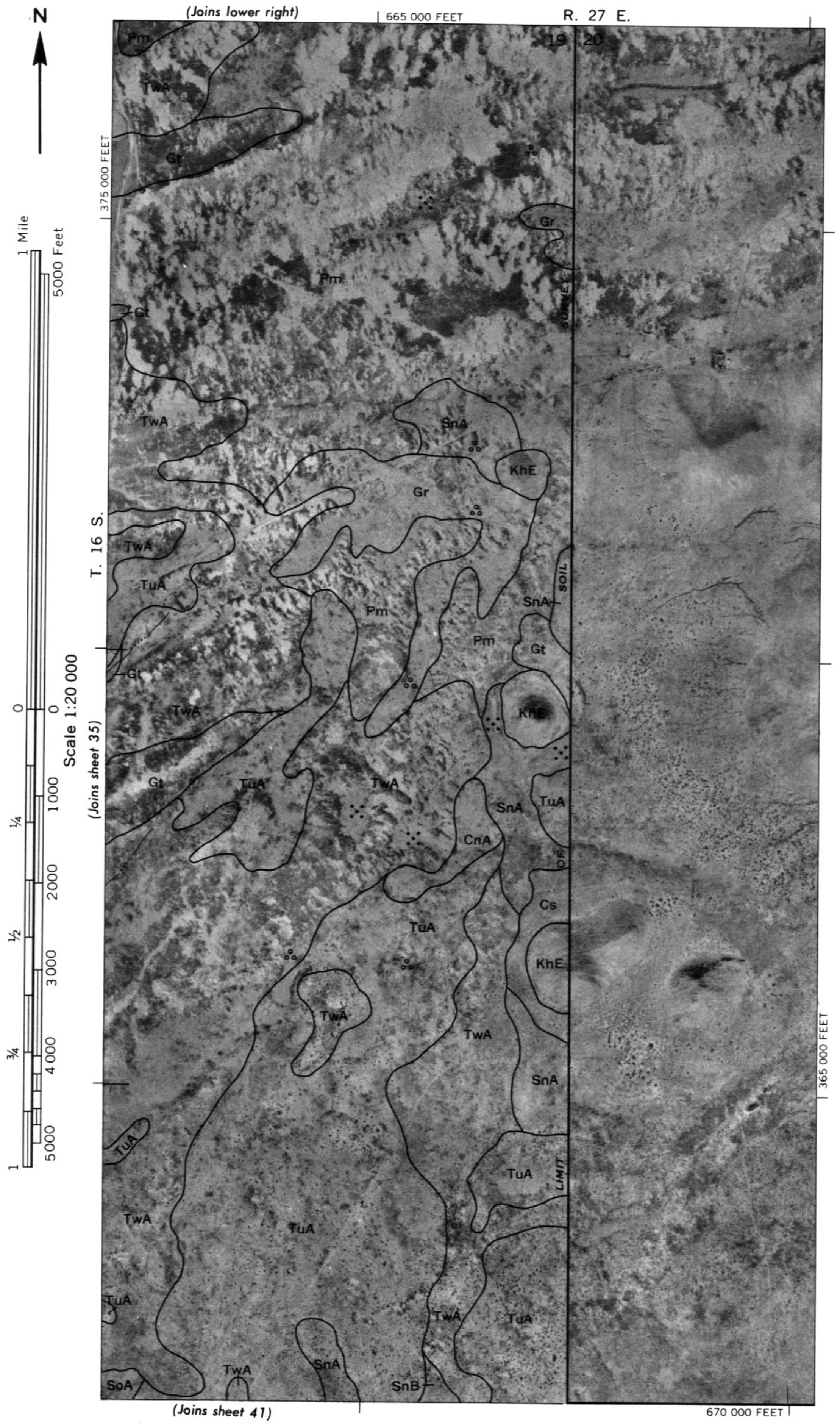
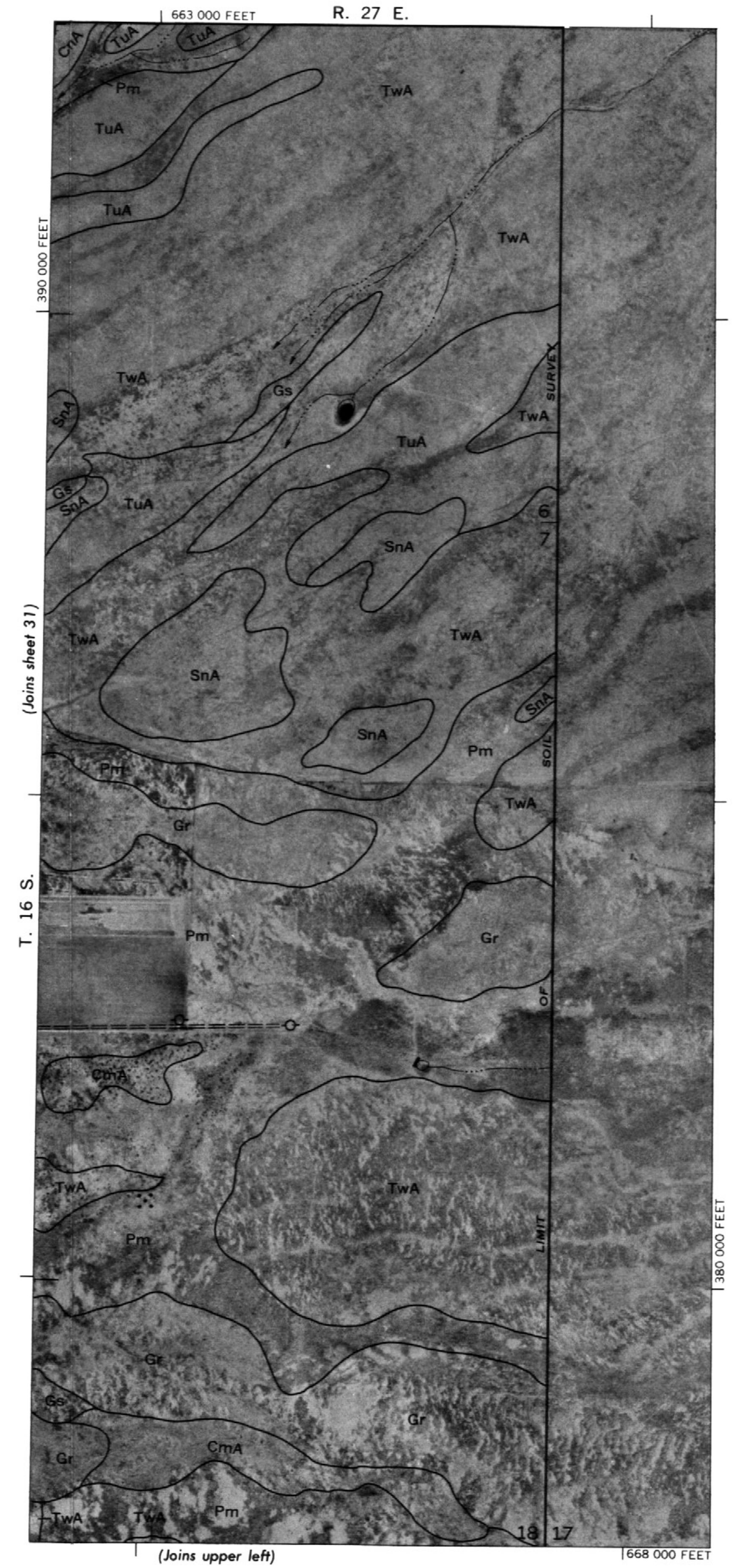
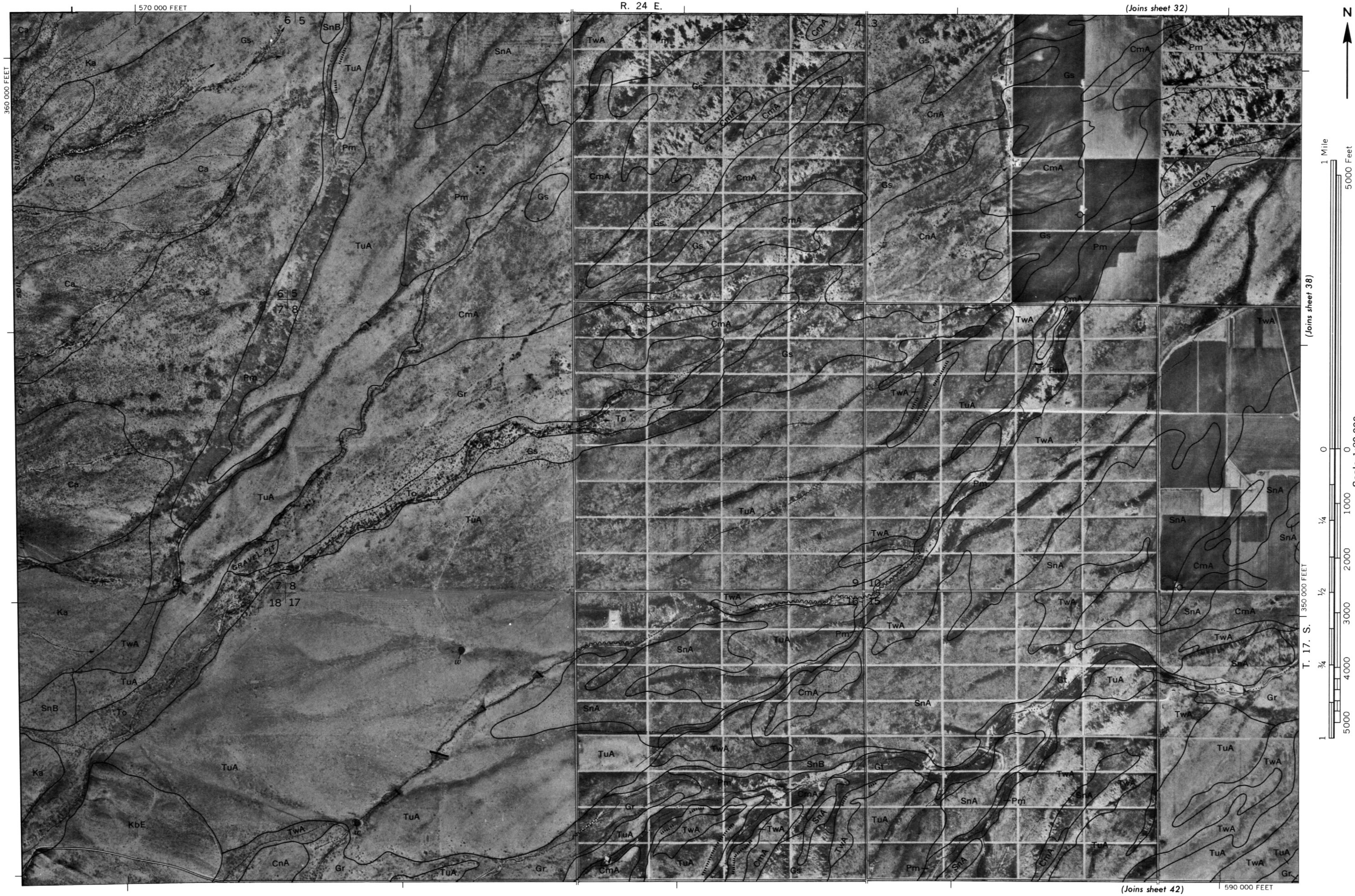




Land Division corners are approximately positioned on this map.

Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.



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Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum.
Land Division corners are approximately positioned on this map.

WILLCOX AREA, ARIZONA — SHEET NUMBER 38

N

Scale 1:20 000

1 Mile | 5000 Feet | 0 | 1000 | ¼ | 2000 | ½ | 3000 | ¾ | 4000 | 5000

(Joins sheet 33)

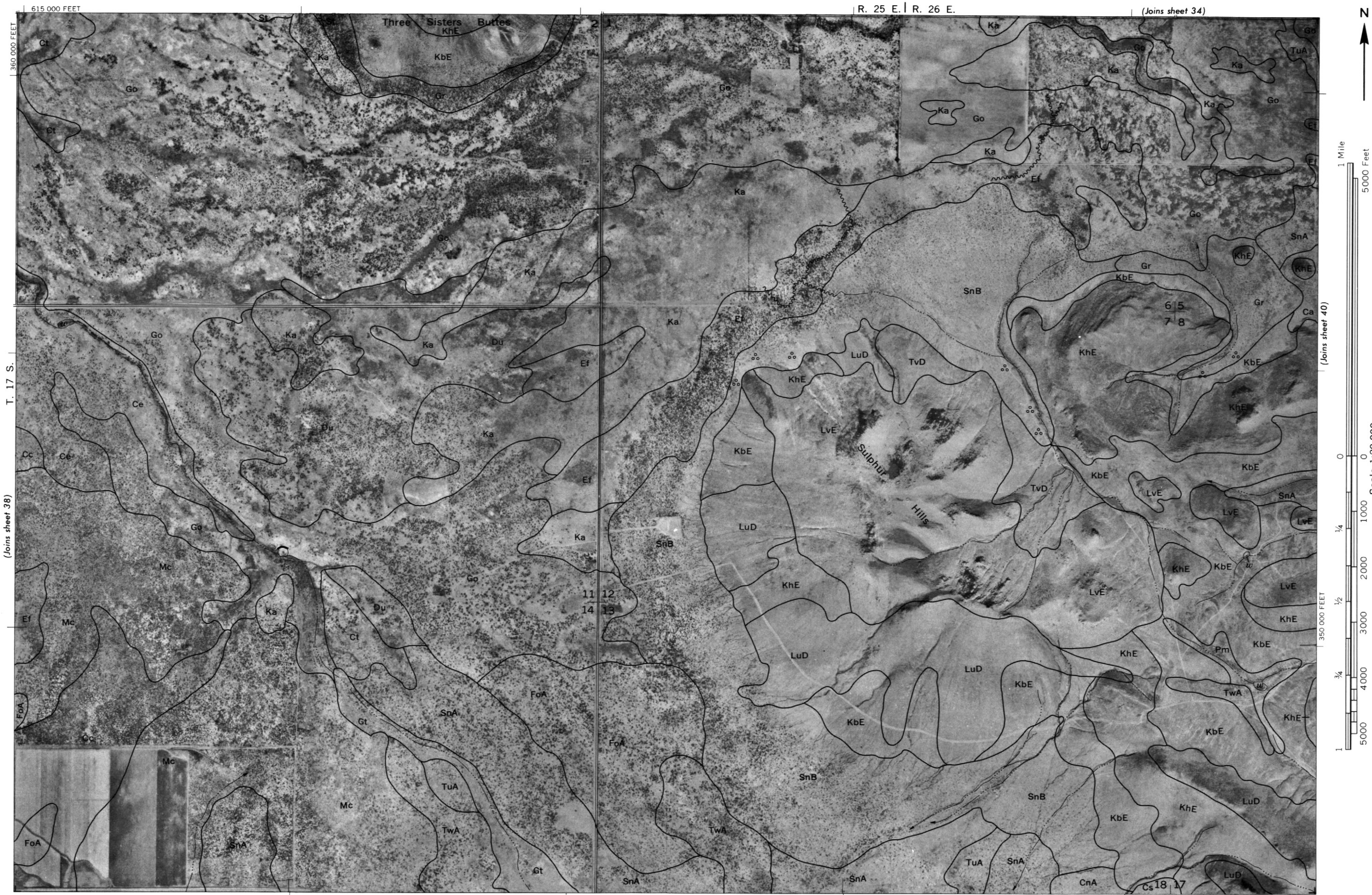
R. 25 E. | R. 24 E.

(Joins sheet 43)

Land Division corners are approximately positioned on this map.

Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.



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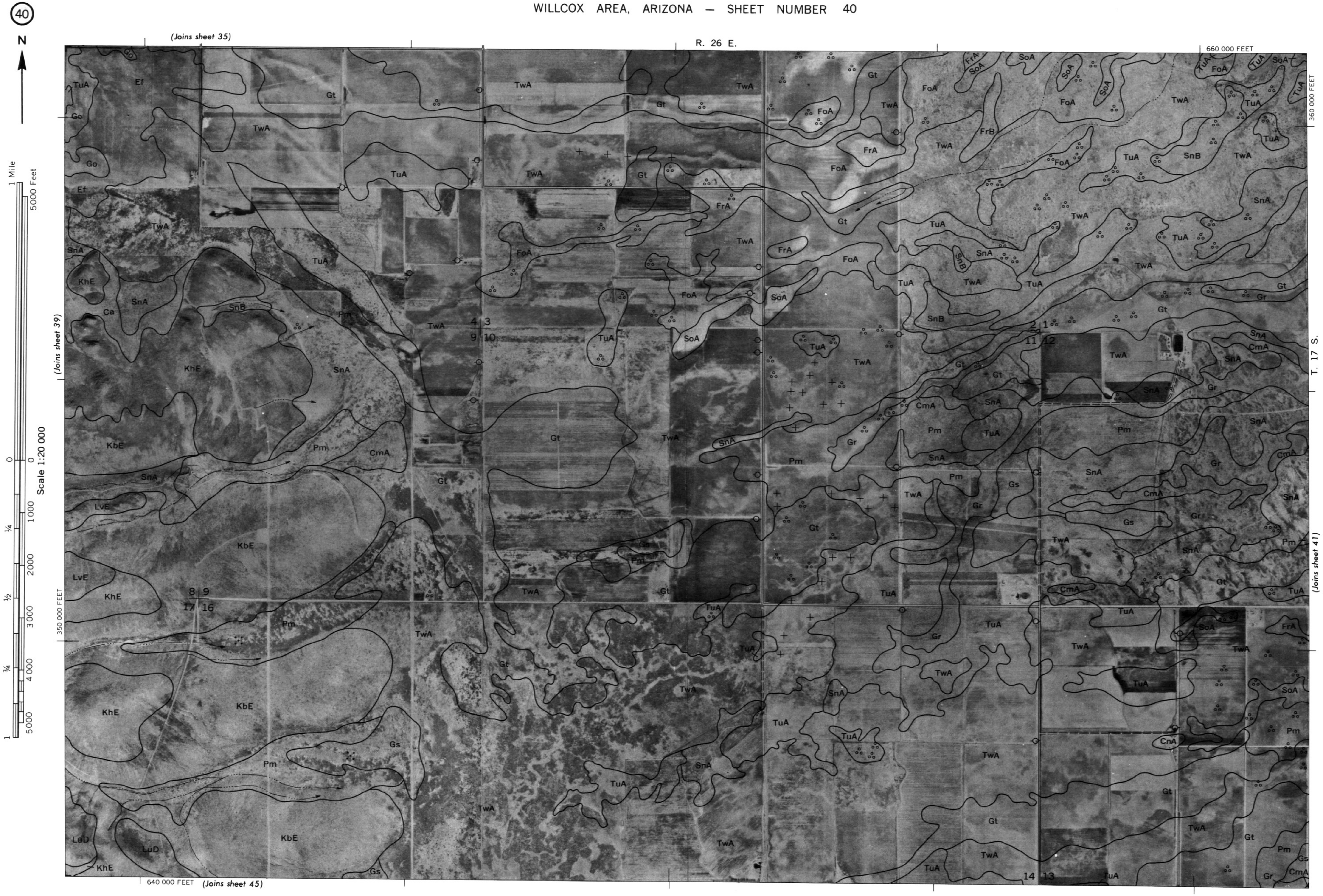
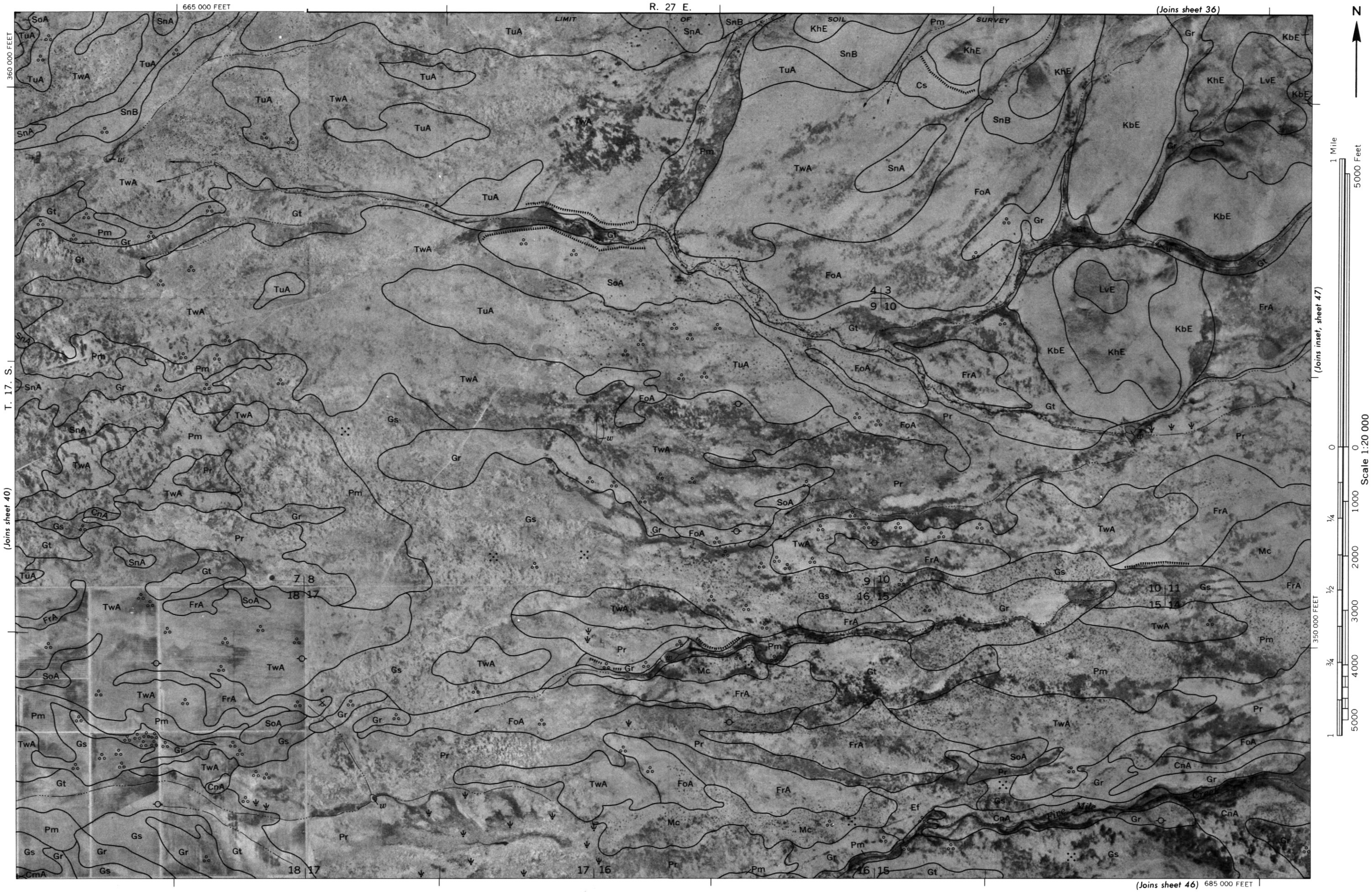
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum.
Land Division corners are approximately positioned on this map.

WILLCOX AREA, ARIZONA — SHEET NUMBER 40

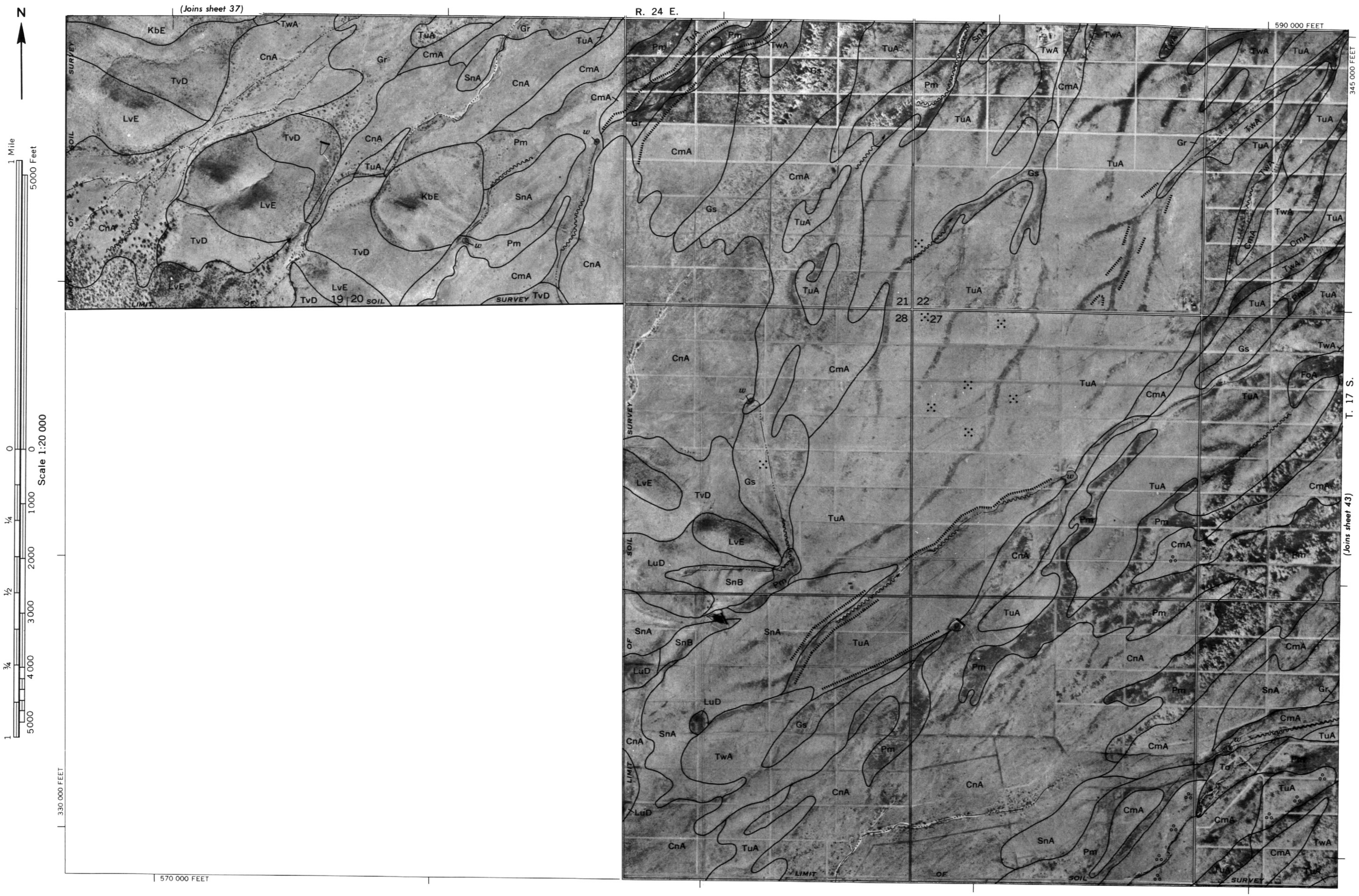


Land Division corners are approximately positioned on this map.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.

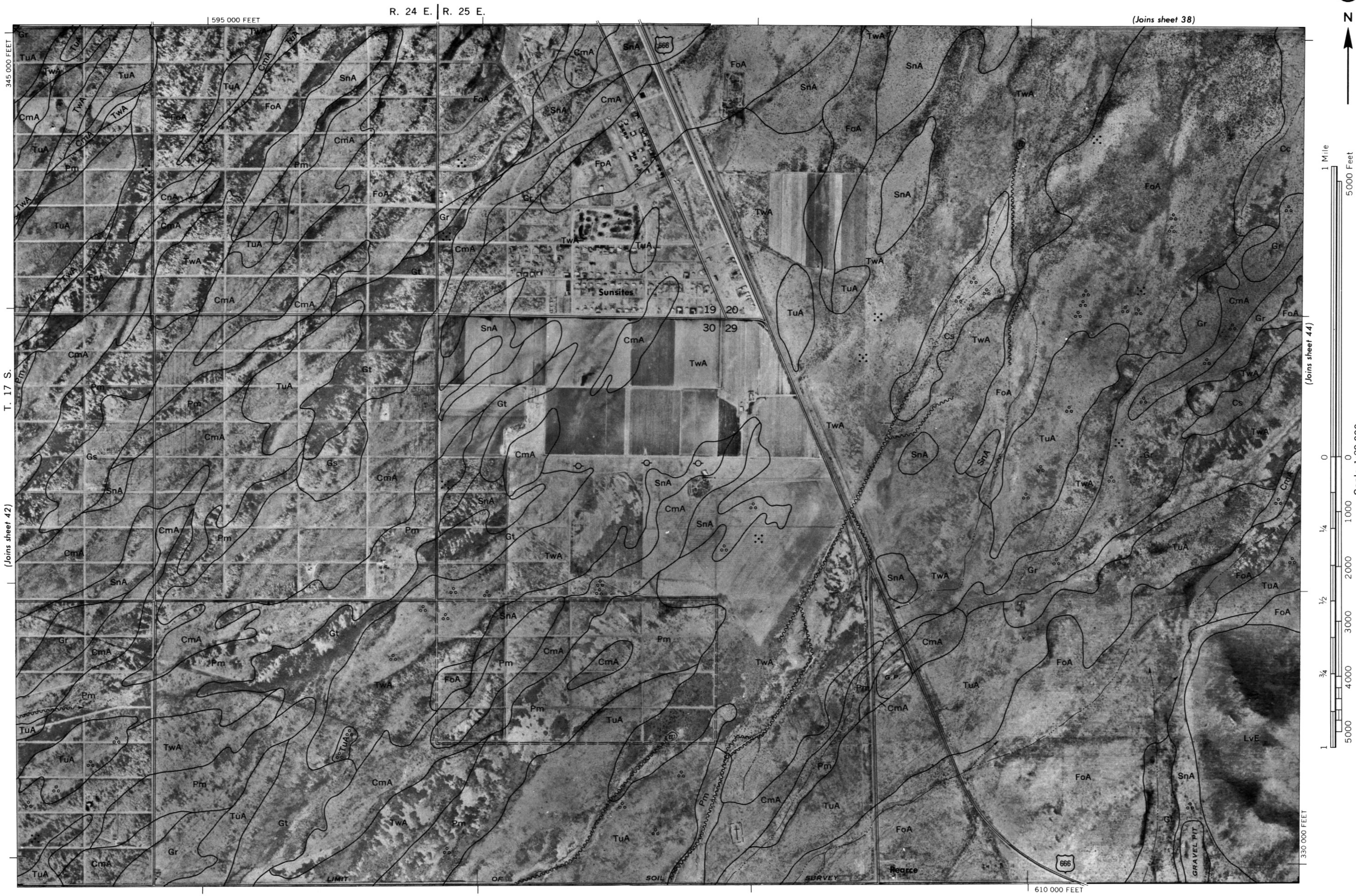


This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum.
Land Division corners are approximately positioned on this map.

WILLCOX AREA, ARIZONA — SHEET NUMBER 42



Land Division corners are approximately positioned on this map.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone, 1927 North American datum.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.



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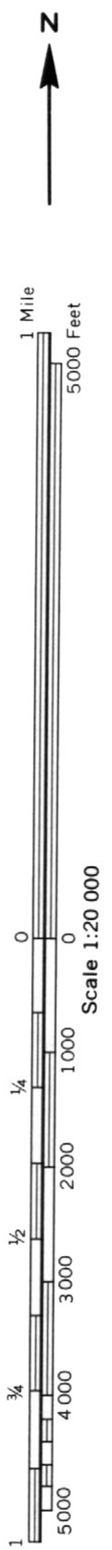
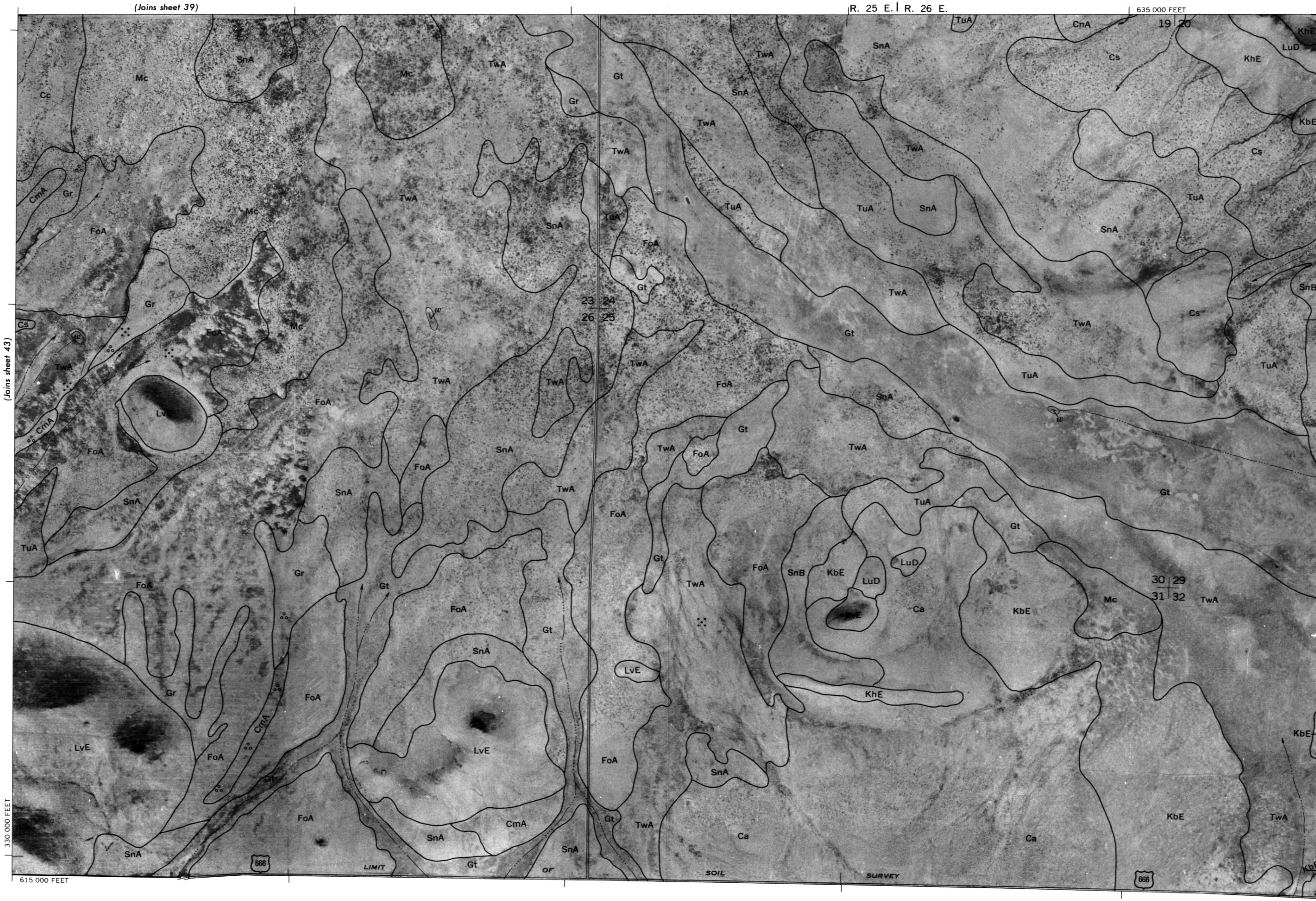
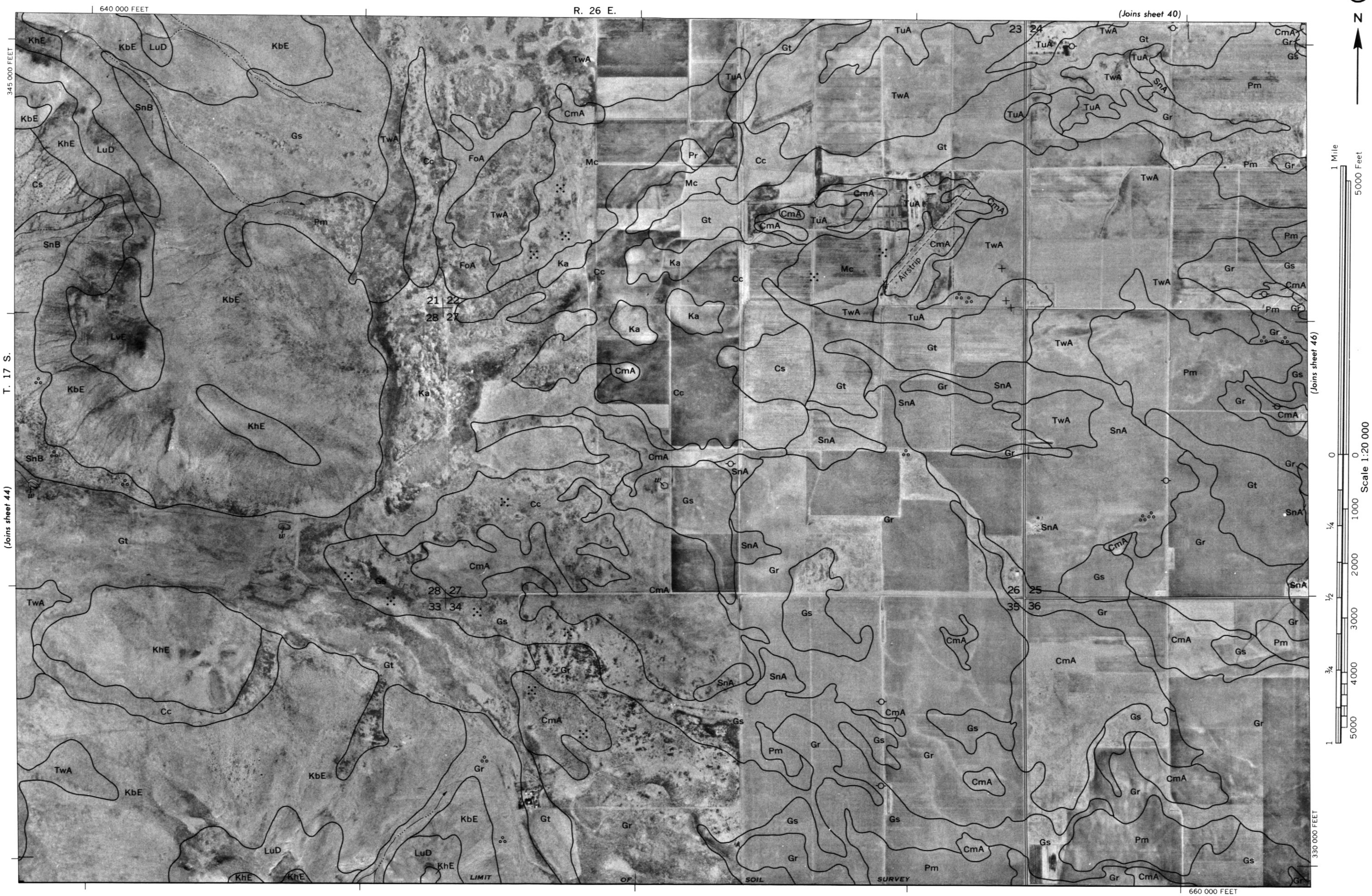
WILLCOX AREA, ARIZONA — SHEET NUMBER 44





Land Division corners are approximately positioned on this map.
Photobase from 1958 and 1964 aerial photography. Positions of 5,000 – foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Arizona Agricultural Experiment Station.



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Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum.
Land Division corners are approximately positioned on this map.

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Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone. 1927 North American datum.

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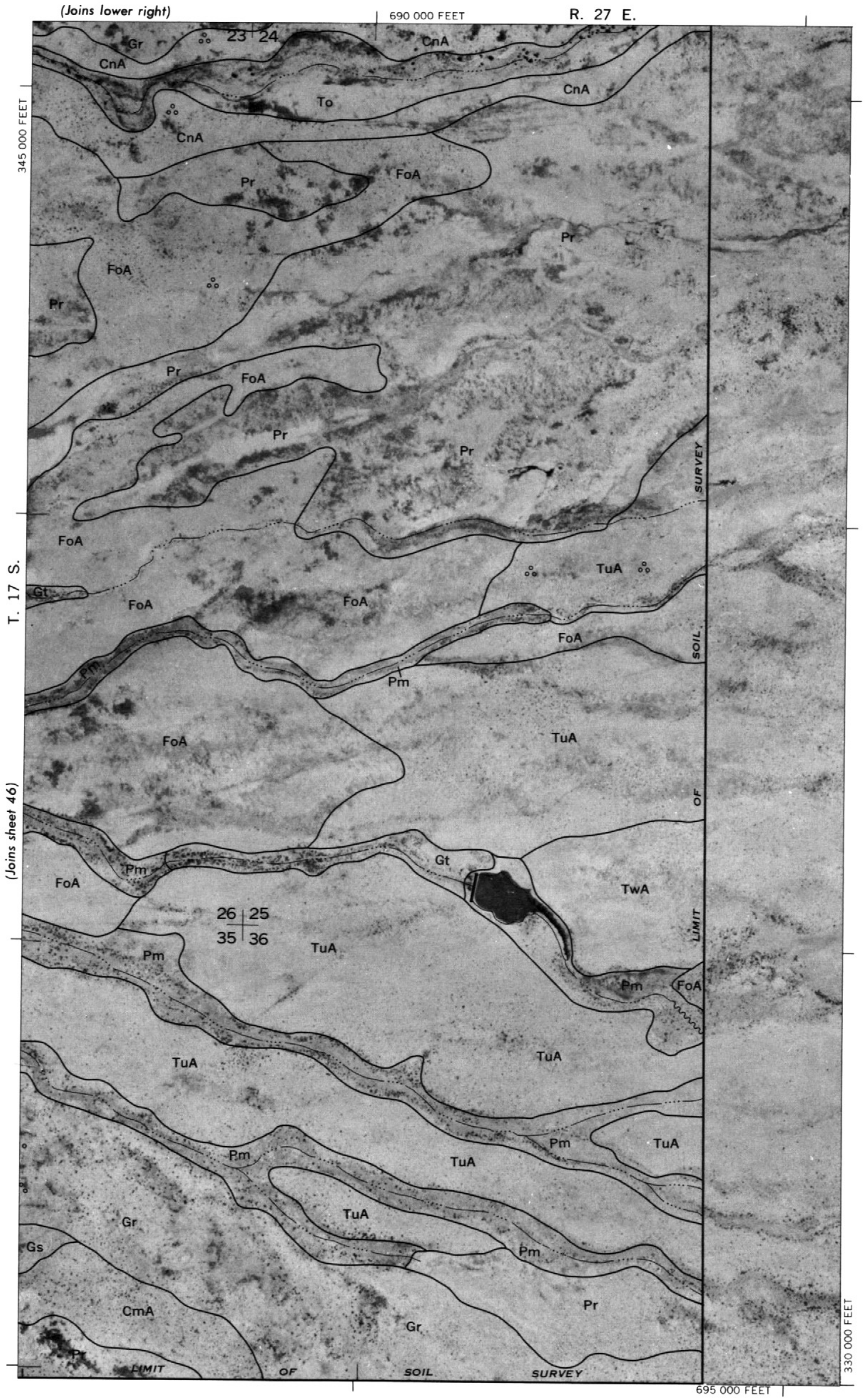

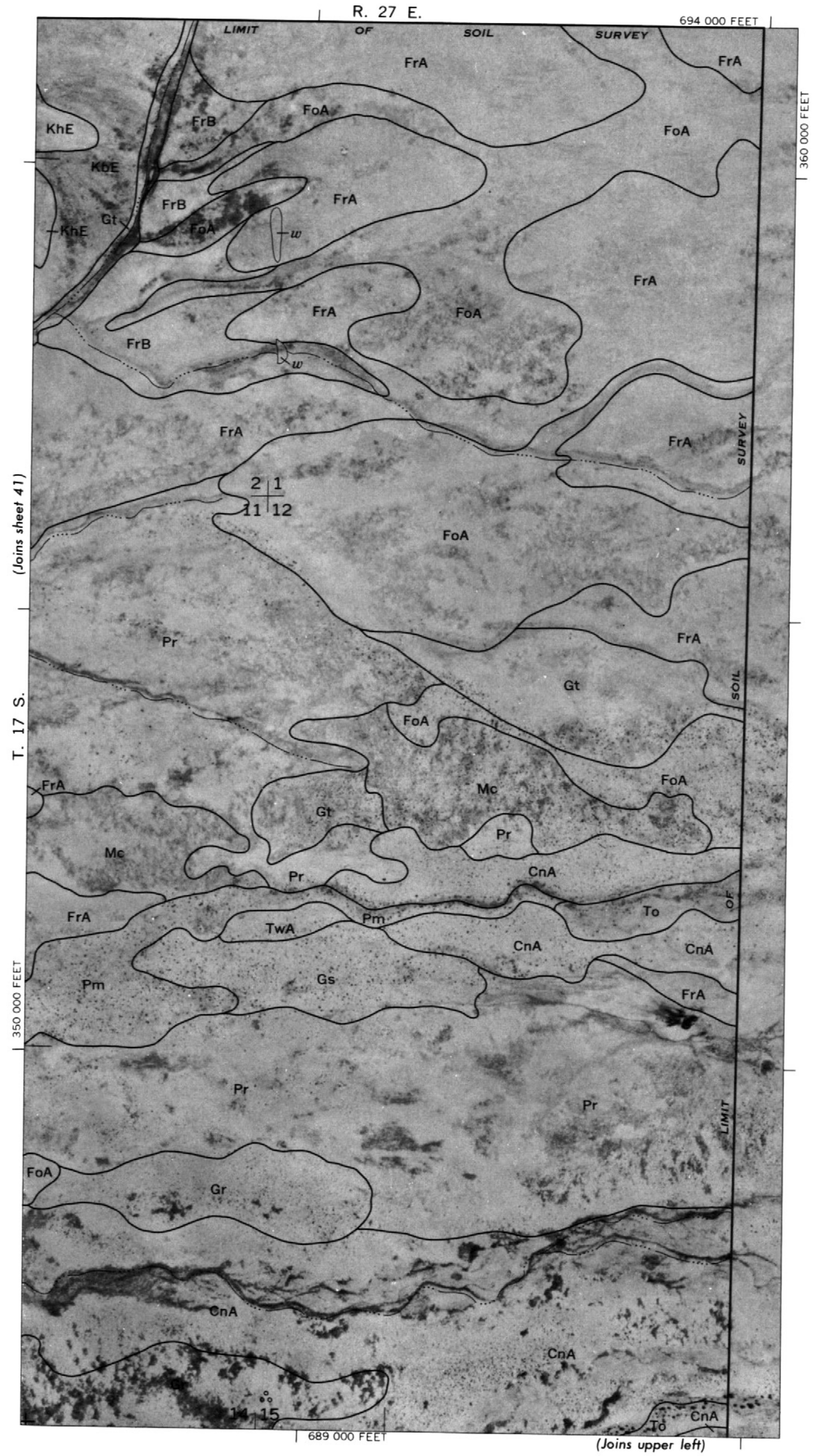

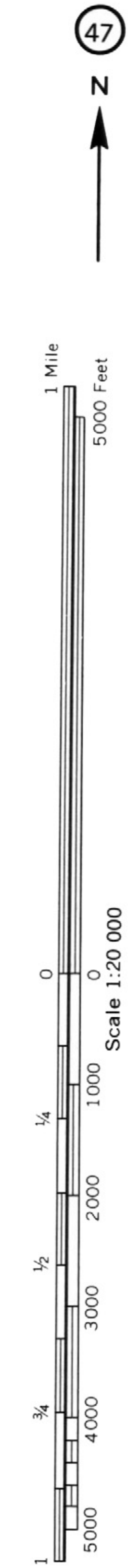

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Photobase from 1958 and 1964 aerial photography. Positions of 5,000 - foot grid ticks are approximate and based on the Arizona coordinate system, east zone 1927 North American datum.
Land Division corners are approximately positioned on this map.